UNITED STATES DEPARTMENT OF AGRICULTURE
FOREST SERVICE



# HANDBOOK
ON
# CONSTRUCTION AND MAINTENANCE OF THE NATIONAL FORESTS' TELEPHONE SYSTEM

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## CONTENTS

# TELEPHONE CONSTRUCTION AND MAINTENANCE ON THE NATIONAL FORESTS

## PURPOSE

The purposes of the handbook are: First, to set forth certain broad policies; second, to describe certain approved types of telephone construction and maintenance (including installation of instruments) and to establish standard specifications for the more important types; third, to explain briefly the fundamental principles involved in the operation of telephone lines and instruments; fourth, to furnish instructions for locating and clearing trouble; and fifth, to describe special methods used and practices followed in different districts which are adaptable to the varying field conditions.

## GENERAL POLICY

The telephone system as an indispensable medium of communication in national forest administration is solidly established.

### PRIORITY

In financing the extension of the system the following priorities will govern:

(1) Lines to insure more effective fire control to a degree fully justifying cost of construction and upkeep.

(2) Lines to facilitate administration in which fire control plays but a very minor part and which will bring forest officers at isolated stations into communication with the outside world.

Lines of class 2 priority will not be financed as a rule until improvements needed to secure better protection against fire are well along toward completion.

## TEMPORARY LINES

Temporary lines of insulated outpost or regulation Forest Service emergency wire to establish communication to camps of crews forming important parts of the fire-control organization should always be strung where the intervening distances between the permanent line and a camp does not render such lines impractical. Temporary lines up to 12 miles or of even greater length are usually warranted in fire forests if the crews are to stay in a given region throughout a material part of the fire season.

## PRIVATE CONNECTIONS

Individuals, companies, and corporations which are a part of the fire-control organization as outlined by the fire plan may be allowed connections to and communication over Forest Service lines either under free or paid permit as may be determined by the district forester.

Permits granting to parties outside of the service the privilege of attaching instruments will be issued in accordance with the special-use regulations. Every permit will stipulate in addition to the printed requirements on the special-use permit:

(1) Type of construction to be used and standard of workmanship expected.
(2) Type of instrument to be attached and methods of installation.
(3) Provisions for maintenance and standard of maintenance expected.
(4) Fire-control service expected.
(5) Rate of payment. (To be standardized for the district by the district forester.)

# USE OF HANDBOOK

The specifications and instructions given herein are confined to the more obvious details and the major principles of telephone-line construction. They are based upon methods and principles the worth and general applicability of which have been proved by experience.

Field officers are not expected to memorize the contents of this handbook. It is expected, however, that field officers will always remember: First, that the handbook is available; second, that it is to be consulted and

studied before starting a job; third, that every man placed in charge of telephone work must have a copy of it, supplemented where necessary by specific written instructions to indicate the parts of the handbook that are applicable to his job; fourth, the instructions it contains will govern on jobs unless physical conditions clearly prevent.

The burden of proof of inapplicability will always be upon the officer who is responsible for getting the work done in accordance with the handbook specifications and instructions.

## PLANS

A telephone-system plan will be developed for each forest. A standard form of plan completed in all details will not be prescribed. The minimum requirements, however, for each forest are:

(1) A map of appropriate scale showing roughly, preferably in crayon, all existing Forest Service and private lines by different symbols and the entire future development needed as far as can be foreseen. This map ordinarily will be changed frequently and should therefore be simple and inexpensive. It will be known as the "Telephone plan map."

(2) Card Form 428 for each project about which enough is definitely known to make a detailed estimate.

(3) A second map to be called the "Progress map," showing the location of the completed telephone lines, private and Forest Service, and each Forest Service project listed on Form 428 to which funds are allotted. Private and Forest Service lines will be shown by different symbols. This map will be the permanent one and will be filed in the forest atlas.

Some of the important points to be considered in the development of telephone-system plans are:

(1) The relation of the proposed line to existing systems, private and Forest Service, local and interforest lines considered.

(2) Load factors, that is, the effect additional mileage and instrument load will have upon the existing sytems.

(3) Switching arrangements needed at different points to break up the "load" and to give clear right of way over trunk lines.

(4) Development required to centralize, so far as practical, switching arrangements at points representing logical locations for central fire dispatchers.

(5) Avoidance of high-voltage transmission, telegraph and other telephone lines as far as practical.

(6) All other factors given due weight, the routes which will render the greatest advantage (*a*) as bases from which to extend emergency lines in case of fire, (*b*) for lines paralleling possible or existing patrol beats, and (*c*) as trunks from which to extend permanent branch lines.

(7) General accessibility of route.

The district forester will make such check of the telephone-system plans as may be necessary to insure adequacy and economy of development, and proper coordination of plans between the systems of different forests and with private or commercial lines.

## LINE CAPACITY

Each telephone or extension bell connected to a line adds resistance and accordingly consumes a certain amount of electric energy. Too many instruments connected to a line load it so heavily electrically that ringing and talking over the line may be seriously hampered. Each connected telephone also usually means added use or traffic. A heavy traffic load is a most objectionable form of interference. In view of these facts every line has its limit as to the number of telephones, extension bells, and repeating coils that can be carried; accordingly "line capacity" is a material factor to be dealt with in the working out of forest communication plans. Lines have the greatest capacity which are free from all forms of physical interferences such as brush, other forms of poor insulation, and from electrical interferences—static—and induction from high-voltage power lines and cross talk from adjacent telephone lines. These are elements that must be considered in estimating the capacity of a given line.

The traffic or use load is a factor on principal trunk lines calling for regulation by most careful planning and supervision. In ordinary practice on the average Forest Service telephone line a total of 10 to 20 standard telephone instruments, extension bells, or repeating coils (see "Telephone instruments," p. 83) may be connected on line units not exceeding 50 miles in length. On longer lines 8, 10, or 12 instruments is about the limit, depending upon the amount of additional wire over 50 miles. A pole line may carry a few more phones, since line leakage is usually less in that type of construction.

These figures do not represent the maximum carrying capacity. They allow a safe margin for the connection of telephone sets in temporary camps during the summer months.

All instruments at unoccupied camps or other points along a line which are installed for occasional use, except when needed, will be cut off the line by means of a switch. Such instruments, depending upon circumstances, may or may not be counted as a part of the ordinary load, in calculating a line's carrying capacity.

### LINE LENGTH

The principal factors to be considered in determining the maximum length of single units of Forest Service telephone lines which may be operated satisfactorily are:

(1) Line leakage. (See "Clearing," p. 14.)
(2) Interference. (See p. 51.)
(3) Number of telephones and amount of use.

Ordinarily, lines extending through dense forests may be operated in units ranging from 40 to 50 miles in length, provided they are not too heavily loaded (having too many telephones connected to them). Through more open country, where probability of line leakage due to brush contacting with the line will be less, lines up to 75 miles in length may be operated satisfactorily. If lines are heavily loaded or if points farther apart are to be reached, two or more line units connected through suitable switching stations must be planned for. From 40 to 50 miles is about the limit for small unit lines over high divides or in any other localities where a considerable volume of static interference may be encountered. (See "Static interference," p. 51.)

## STANDARDS AND SPECIFICATIONS

### TYPE OF LINE

Except for line interference (see "Interference," p. 51), it is possible to talk and ring as far over a grounded-circuit (one-wire) line as over a metallic-circuit (two-wire) line. Therefore grounded-circuit lines will be considered standard. and the construction of a metallic-circuit line will be authorized only for the purpose of eliminating electrical interference.

## TYPE OF CONSTRUCTION

Tree lines will be used wherever practicable.
Pole lines will be built only where—
(1) Trees are not available on a feasible and practical route.
(2) It is necessary to construct metallic-circuit lines to eliminate electrical interference.

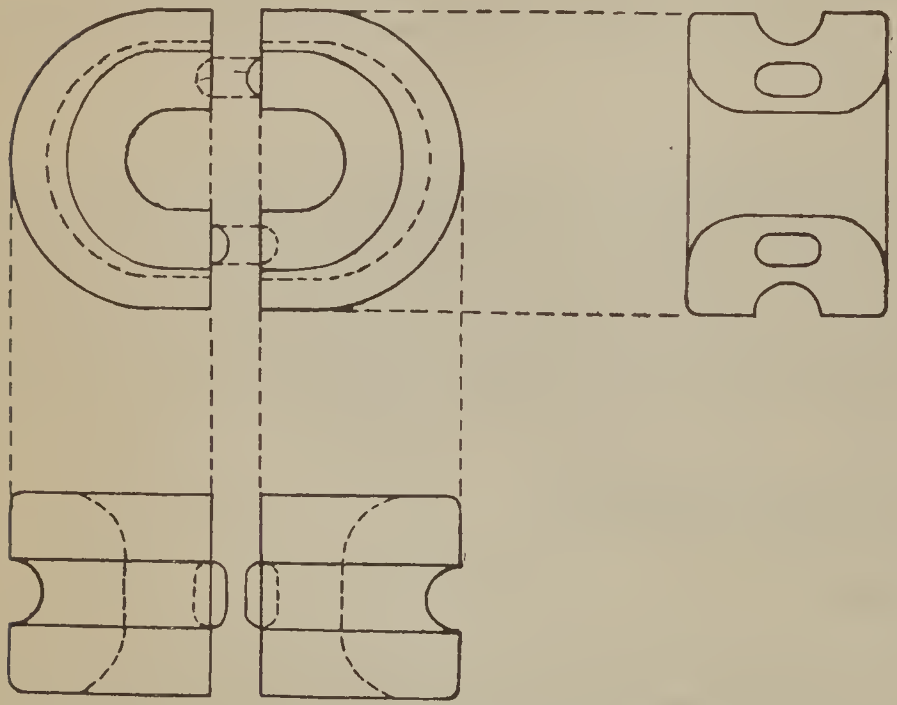


FIG. 1.—Split tree insulator. (To be made from white or brown finished porcelain)

## TEMPORARY LINES

Temporary lines of insulated wire will be laid out so as to insure least damage by travelers, stock, and game.

## LINE WIRE, IRON

Number 9EBB galvanized-iron wire will be used for all permanent lines except as hereafter noted:

(1) Long spans (see p. 18), where No. 8 galvanized-steel wire will be used.

(2) Where a less costly line will give a standard of performance satisfactory to all requirements, such as, for example, (*a*) branch lines connecting to and operating through a switch from the main lines in regions where snowfall is not a material factor of damage, or if located below such snow belts; (*b*) independent short lines which never will become a part of any major system.

(3) Below such snow belts in cooperative lines to which the service contributes but a minor share of the costs.

No. 12EBB wire will be used for exceptions (2) and (3).

## TREE INSULATORS

The split tree insulator shown in Figure 1 is standard.

## STAPLES AND WIRE RINGS

Bright or galvanized iron staples are indorsed as the most satisfactory type of hanger support, economy and all other relevant factors considered, for attaching hangers to trees except:

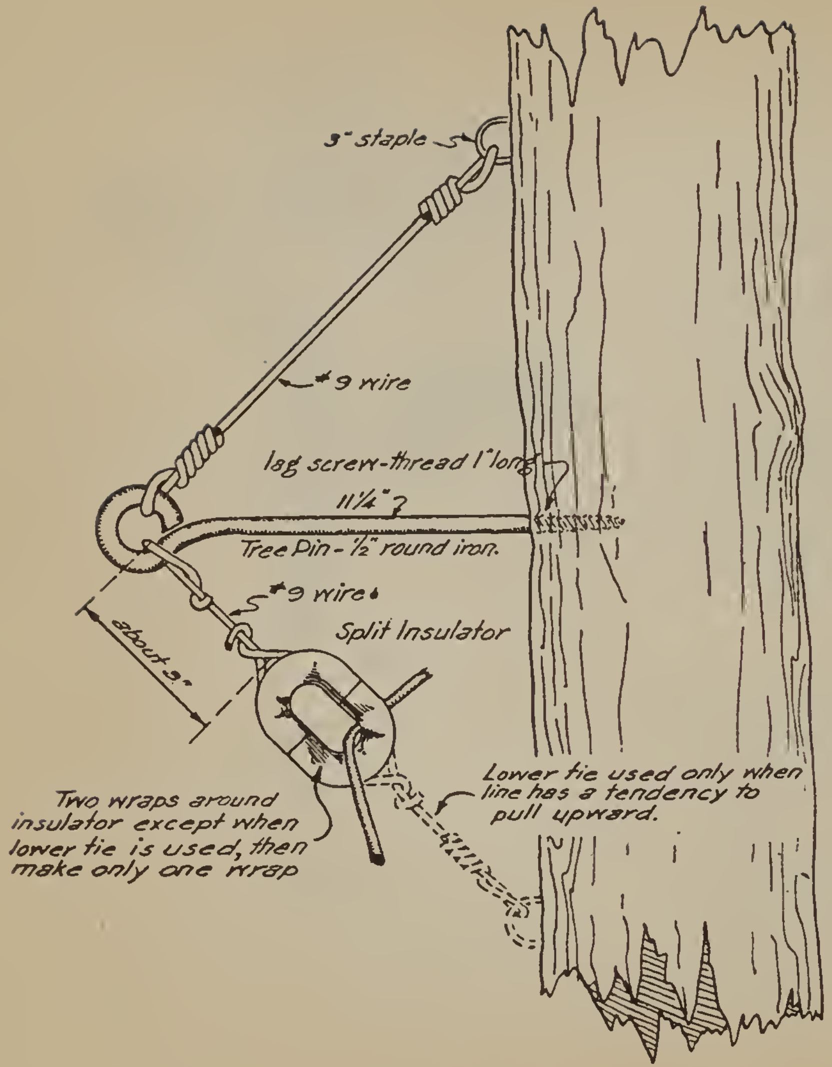
(1) Where special devices are necessary to avoid probability of "tree grounds" when the pull is unavoidably toward the tie tree. (See paragraph "Hooks and pins," p. 7.)

(2) In the woodland type, where small diameters of oaks, aspens, etc., frequently render use of hooks impracticable, a satisfactory substitute device of proved merit is illustrated in Figure 2. It is a ring of No. 9 line wire at least 4 inches larger in diameter than the support tree. Ordinarily it can be kept at desired elevation by hanging it over a limb left on the rear side of the tree.

## TREE HOOKS AND PINS

The use of tree hooks or pins as illustrated in Figures 3, 4, 5, 6, 7, and 8 have certain advantages, but at present these do not appear sufficient to warrant their adoption as standard in preference to 3 or 4 inch staples. Their use is left optional with the district foresters. Figures 3, 4, and 5 illustrate devices used in district 6 for attaching to tie trees not sufficiently out of alignment to give a pull-away effect, thus one way of avoiding the probability of the lines grounding against the tree. That method also has merit for use along roads where it is desired to have the wire and insulator always on the road side of a tree, without regard to whether the pull is away from or toward the tree.

FIG. 2.—Wire ring. Hanger support




## HANGERS

Two general types of hangers have been developed, each efficient under given sets of climatic and forest conditions.

Figures 9 and 10 illustrate hangers which best meet the requirement in old burns and in the northern country, where windfall is the chief source of line damage. The object under such conditions is to provide a type of hanger that gives way under a relatively small strain, since windfalls in large volume are likely to occur on short stretches of line at approximately the same time. Where this condition prevails the line is hung up to come down easily.

The second type of hanger (figs. 11, 12, and 13) is adapted for use where only the occasional falling snag or tree represents a limited damage risk, but where heavy snow load and high winds are encountered.

There the line wire is hung with the idea of securing greater permanence, but providing for a safe margin of difference between the breaking or stripping factor of the hanger and the breaking strain of the line wire.

FIG. 3.—Iron tree pin. For use in trees too small for the wood pin. The iron pin should not be used in trees likely to be used in logging operations. The lower tie need not be made if the wire in its upward rise will swing free

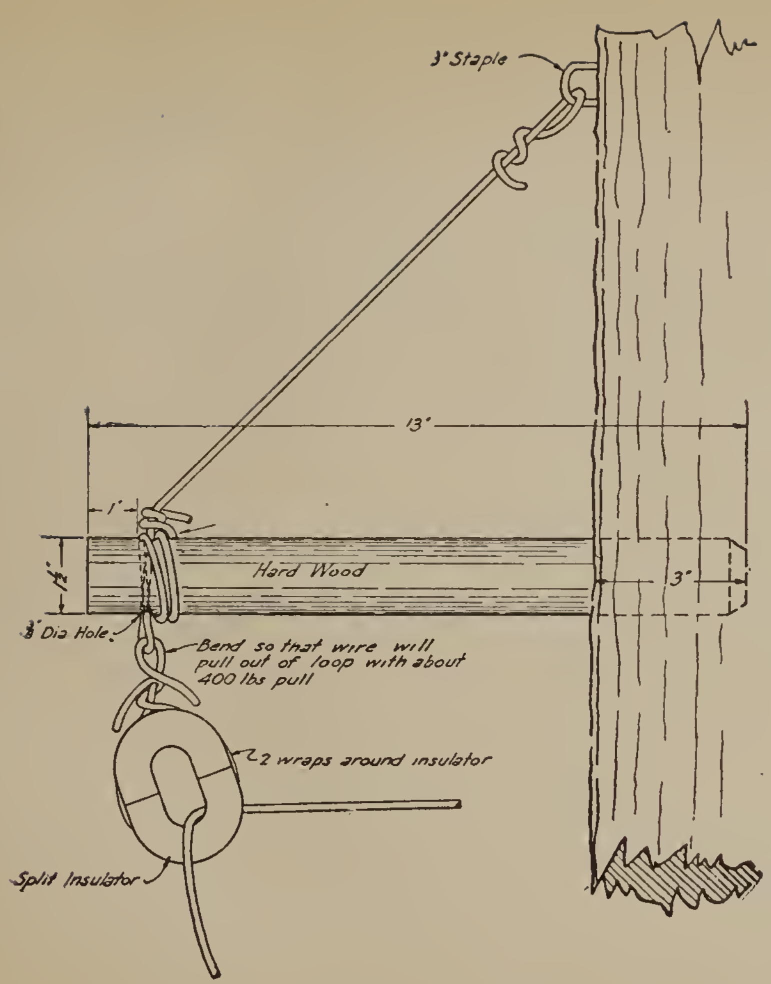



FIG. 4.—Wooden tree pin

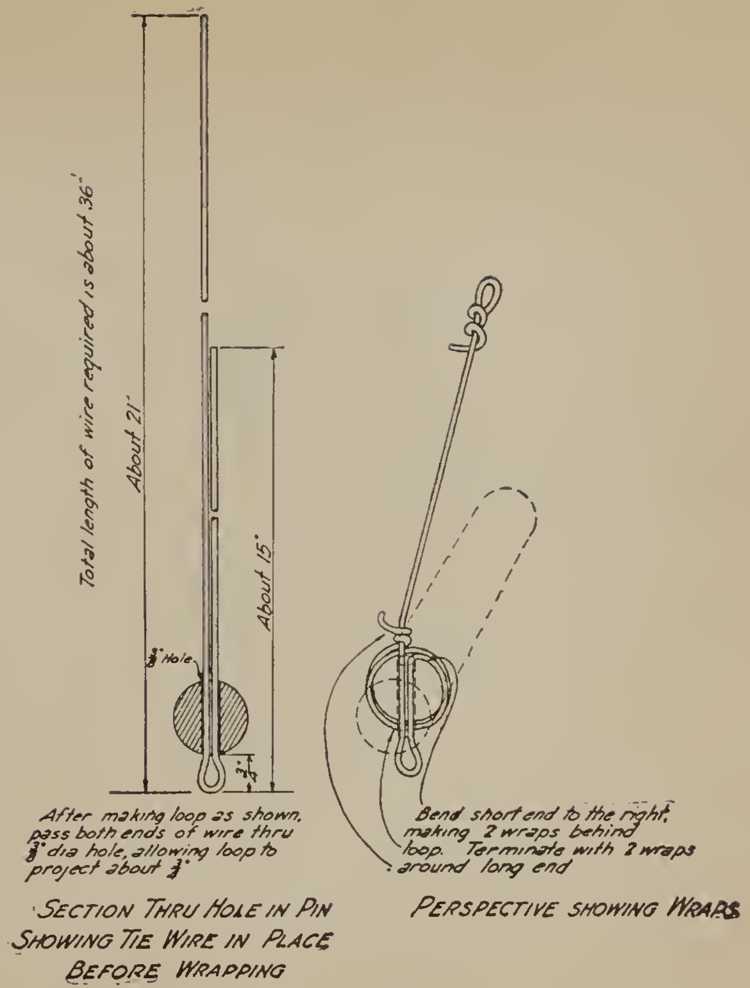



FIG. 5.—Method of making tie for wooden tree pin

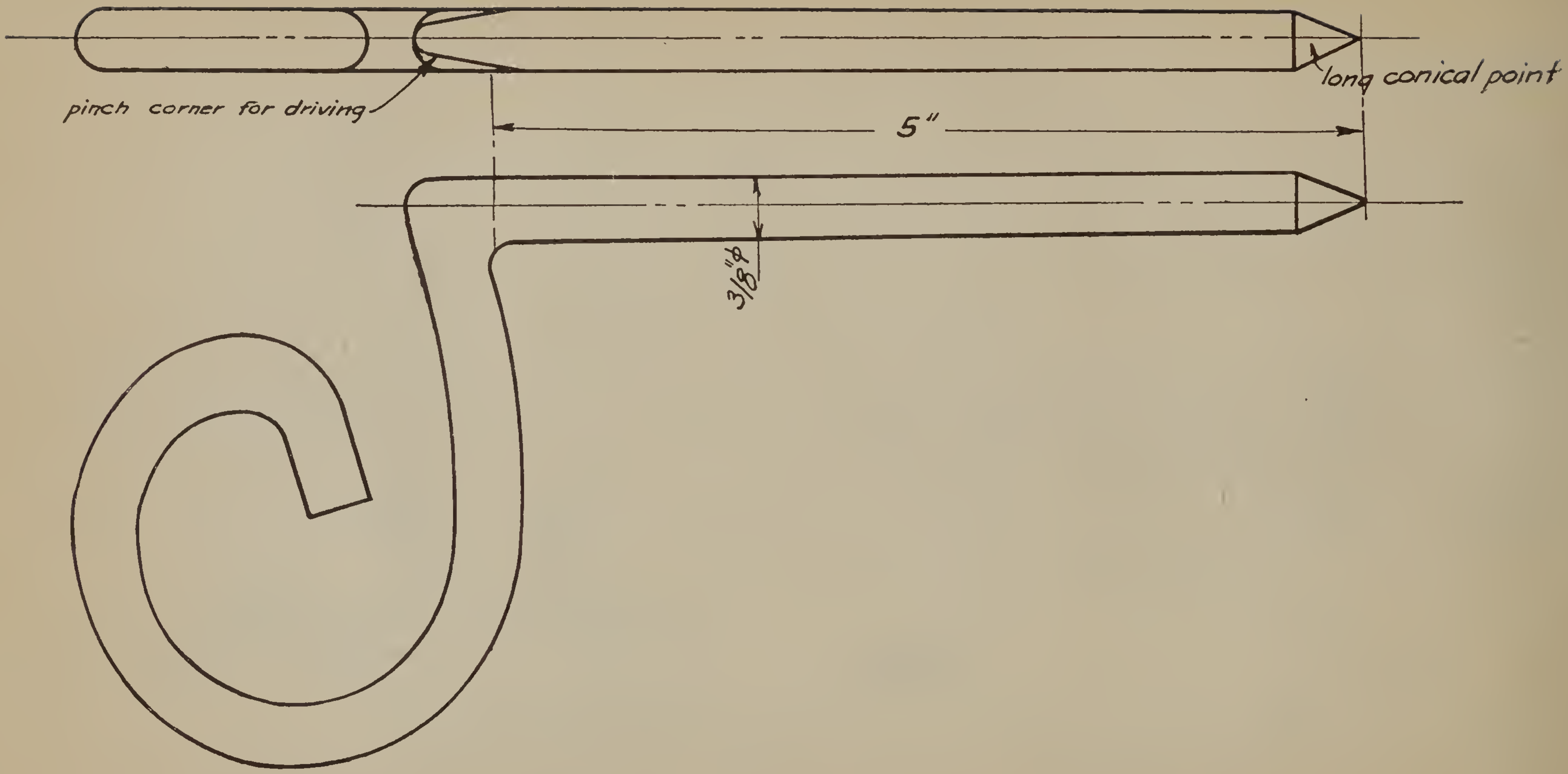



Fig. 6.—Telephone tree hook

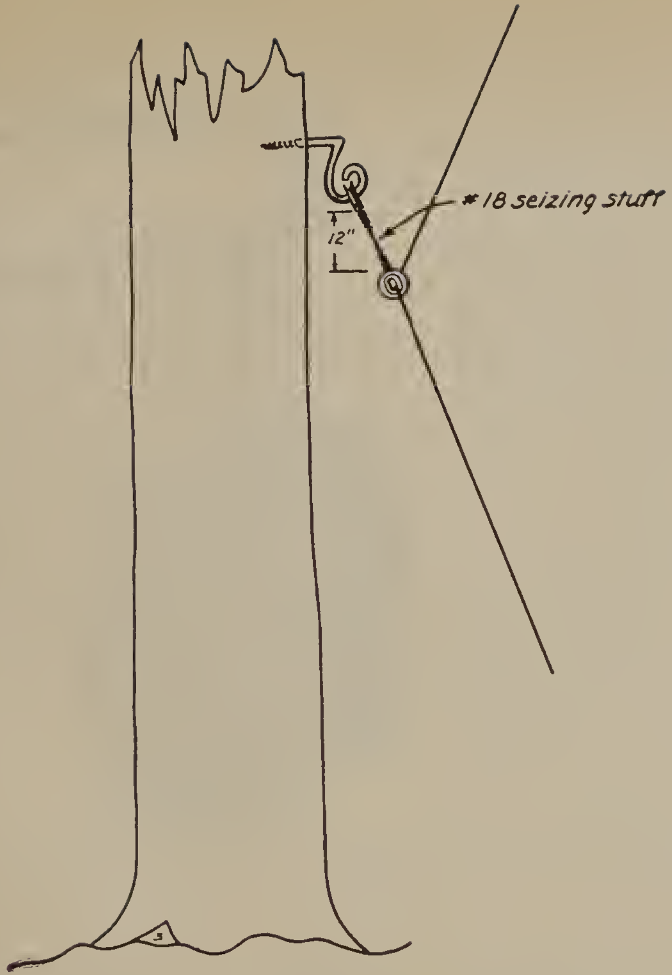



FIG. 7.—Tree with hook and hanger and section of line. Wire pulling away from tree

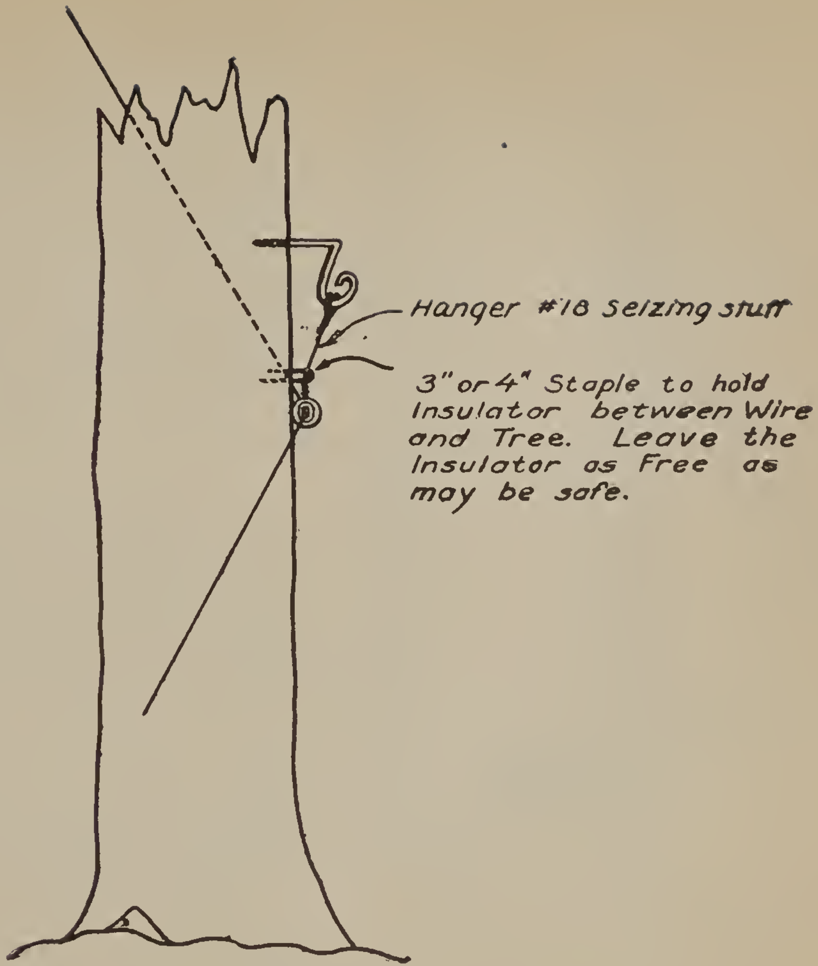



FIG. 8.—Tree with hook and hanger and section of line. Wire pulling toward tree

This type of hanger is advocated for use in California, Arizona, New Mexico, and the yellow-pine site of southern Idaho and eastern Oregon, and in district 7.

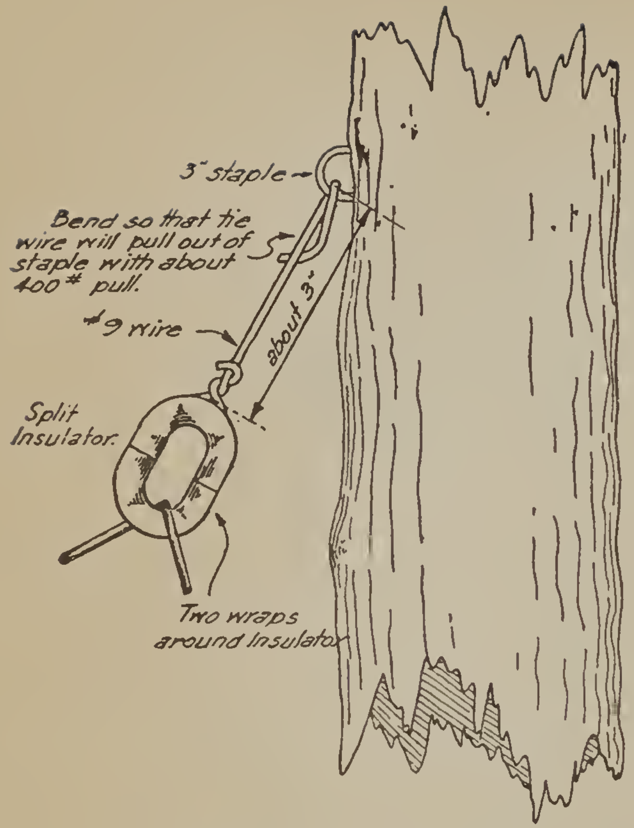



FIG. 9.—Hanger. Pull-away method

The thimble at the upper end is used to insure free play of the hanger on its support. This reduces the internal strains in the hanger strand itself, thus making for less probability of crystallization and consequent breakage at the shoulder on top of the insulator and at the end of the loop, which otherwise would pass through a staple or around a hook.


FIG. 10.—Method of attaching split-tree insulator

## LOCATION OF LINES

A preliminary survey is always essential with the object in mind of selecting the best practical route, initial cost and maintenance expense being carefully considered. The cautions outlined under "Plans" (p. 13) will also be observed. In the details of location the following specifications will govern to the limit of their practicability.

Lines will be located—

(1) To minimize trouble from (*a*) high winds, (*b*) falling timber, (*c*) deep snow, (*d*) snow and land slides, (*e*) proximity of other grounded telephone and telegraph lines, (*f*) electric transmission lines.

(Telephone lines and electric transmission lines should be avoided, even at a considerable additional expense.)

(2) Adjacent to and in plain view from roads and trails. (Short cuts along which the line will be totally obscured from view from a road or trail will be avoided as a rule. Savings in construction costs can sometimes be made by short-cutting across canyons, switchbacks, etc., but such savings must be very material indeed to justify placing the line out of sight of the road or trail.)

(3) Along roads and trails so that the wire will not fall across the traveled way if hangers should break or if the line is borne down by weight of snow or fallen timber. (See exception for line along foot trails.)

(4) To avoid crossing railroad tracks and main highways.

(5) Along the lower side of railroad tracks.

(6) To avoid the use of poles. (It is a better plan to skirt a meadow or a park by hanging wire on bordering trees than to seek nice alignment and higher standards of visibility of the proposed line by building on poles across such openings. Likewise rather than cross rock stretches, which necessitate blasting for poles or the construction of tripods, detour to trees if they are available along reasonably accessible routes.)

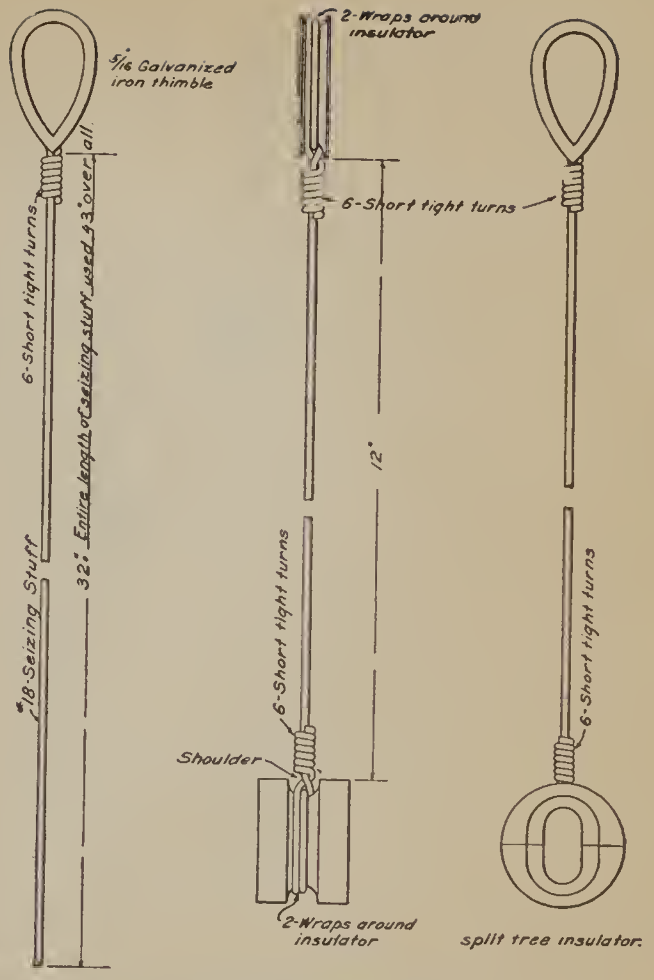



FIG. 11.—Specification of hanger of No. 18 seizing strand

## RIGHTS OF WAY

If it is proposed to build any part of a line across private land within or outside the forest boundary, written right-of-way permits on regulation district forms will first be obtained. Verbal permission is not sufficient.

If the wire is to be strung upon poles belonging to an individual or a corporation, written permission will be secured before any construction is begun.

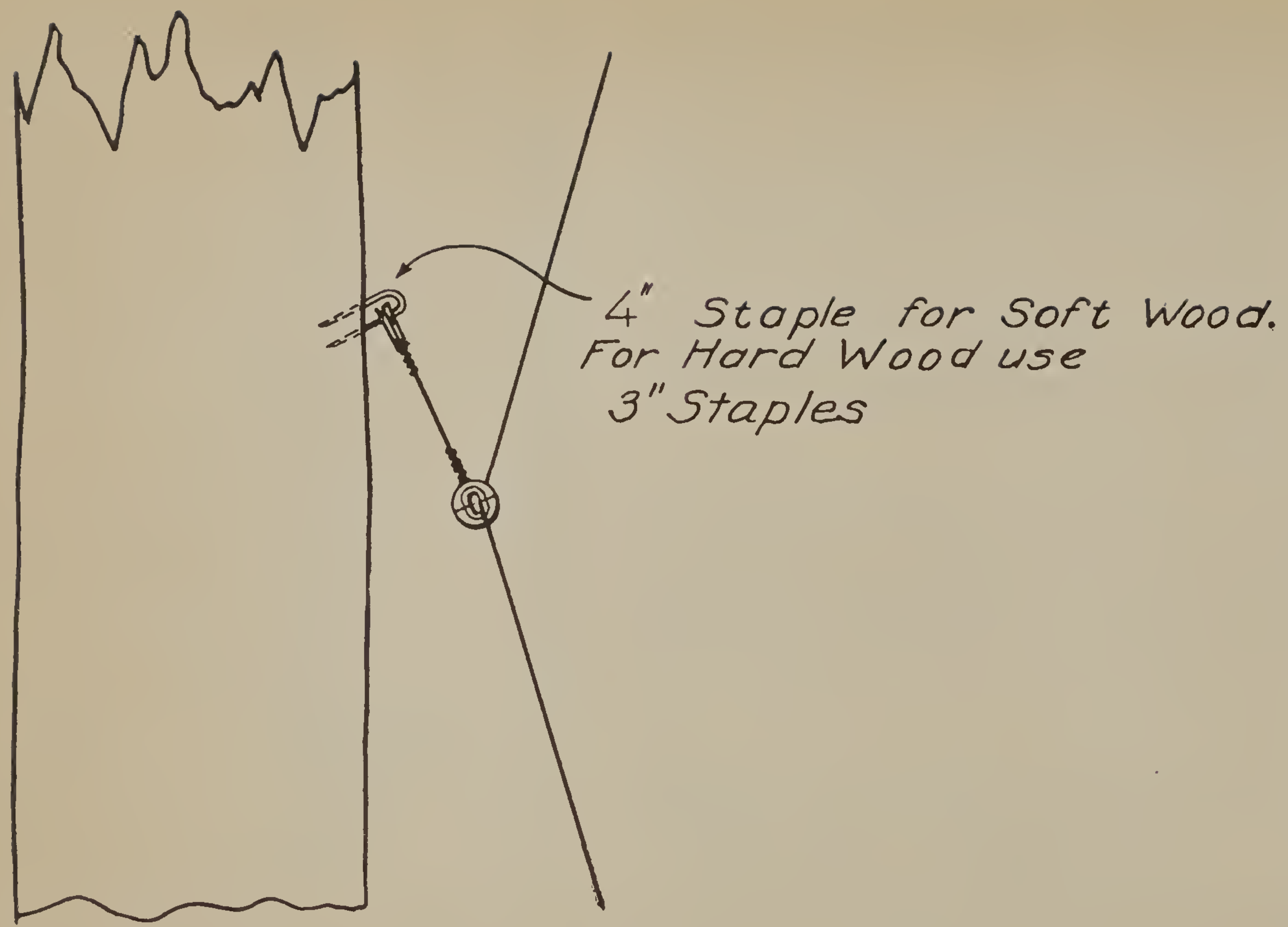



FIG. 12.—Tree with standard staple and hanger (fig. 11) and section of line. Wire pulling away from tree

## CLEARING

Do not swamp out a separate right of way for a telephone line along roads or trails in whole or in part unless to do so is necessary in order to carry out the instructions of "Location of lines." Utilize the clearing of the road or trails as much as those instructions permit.

So far as practicable do all necessary clearing for the line prior to the unreeling of the wire. To do so facilitates the stringing and the raising of the wire into place. The hooks, pins, and staples may also be more easily attached after clearing is partially done. When the wire is in place, cut any remaining obstruction to a distance of 3 or 4 feet from the wire. Be sure to cut away all branches which might possibly interfere with the line when snow laden. Growing trees under the wire will also be removed. Thorough line clearing

is essential to prevent line leakage—loss of the ringing and talking current—which will result if the wire is allowed to come in contact with branches and tree trunks.

Trimming of trees needs to be done only on the line side of tie trees and on obstructing intermediate trees. Tie trees on main traveled roads, however, should be neatly trimmed on all sides. Where esthetic considerations are not involved, it is permissible to leave sufficient stubs of branches to facilitate climbing.

Where practicable, it is desirable to fall all snags which may fall over the line. The falling of snags is usually practicable except in the old Douglas-fir burns in Oregon and Washington and in the vast deadenings of Idaho and Montana.

Rotten snags menacing a line should always be felled. Many snags may be cheaply disposed of along telephone lines by burning them down if the job is undertaken during a period of no fire danger.

## BRUSH DISPOSAL

The district forester will establish brush-disposal practice appropriate to different sets of conditions or different regions. The methods used should not be more costly than required by demonstrable needs on account of fire danger and demands of the traveling public.

## CONSTRUCTION, TREE LINES

The essential features of this type of construction are: First, a slack line, supported by trees instead of poles; second,

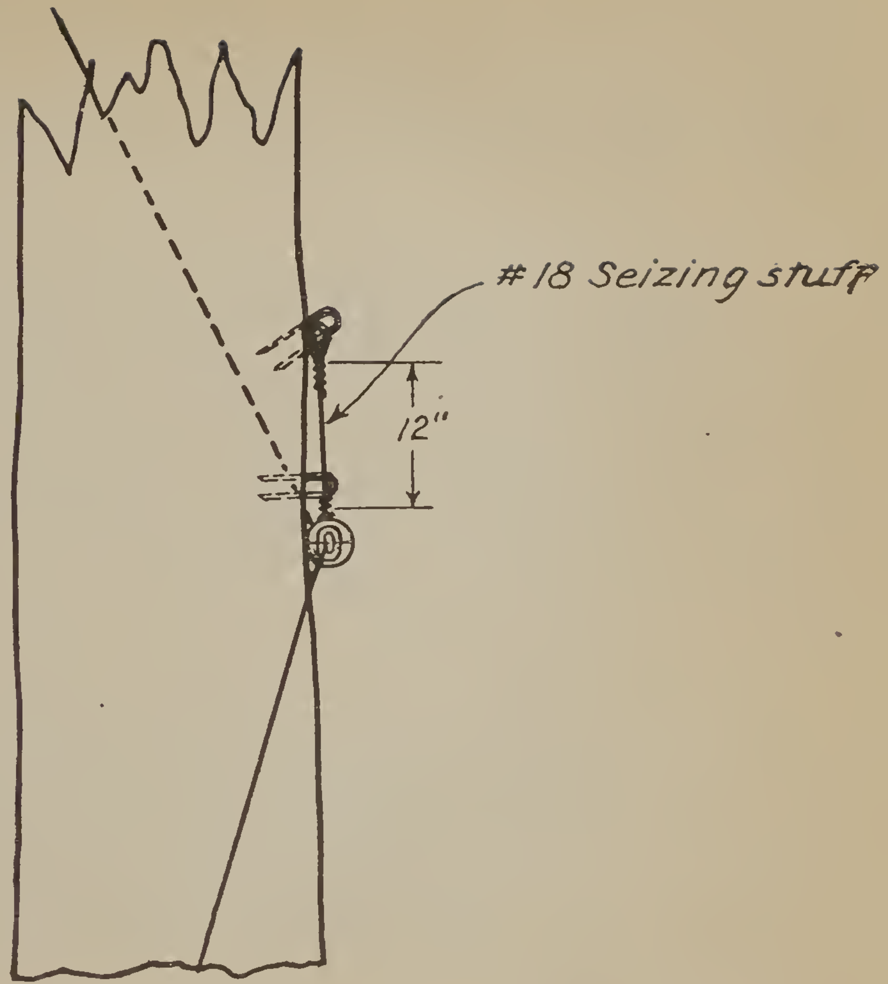


FIG. 13.—Tree with standard staple and hanger (fig. 11) and section of line. Wire pulling toward tree

insulators hung so as to swing freely from the supporting tree and through which the line wire may easily slide in either direction as contrasted with the fixed tie of a tight line to the standard type of insulators common in pole line construction.

To avoid a "tree ground" at the insulator, where the line pull is toward the tie tree, the loose swing of the hanger and insulators usually must be sacrificed. (Figs. 4 and 8.)

## TIE TREES

Select sound trees sufficiently out of alignment to prevent either the wire or insulator touching the trees, and of sufficient size to minimize sway. Only if unavoidable use tie trees which will throw a sharp turn in the line. So far as practicable avoid large trees which are difficult to climb or likely to be cut in logging operations. On account of the rapid growth of sprouts on oaks, alder, vine maple, etc., do not attach to these trees if other species are available. If material is at hand, it is better to set occasional poles (or to build tripods if not in a stock country) than it is to use unusually long spans in snow country, or to make detours which will place the line wire out of sight in inaccessible locations. If poles are used in these circumstances, suspend the wire in the same method as described for trees. (Refer to p. 15.) In some cases it may be best to use the wire ring (fig. 2) on poles to support the hanger, the ring to be held in place with a short staple or nail on the side of the pole away from the line

## HEIGHT OF WIRE

Ordinarily, attach the hanger to the tree at such elevation that the insulator will be at a height of from 15 to 18 feet. This will secure an average ground clearance at lowest point of line of about 12 feet.

When long hangers are used, be sure that they are attached high enough to secure regulation clearance. This is particularly important if the line is hung along a trail right of way.

In regions of deep snow, if practicable, hang the wire above the snow level of deepest snow. Where these conditions prevail, the object is to keep all the line high enough to prevent it being "snowed under," the result of which is a badly broken line when the snow begins to settle.

Over rolling country be certain that ties are so placed as to get proper elevation of wire over each knoll or rise of the ground.

## SPANS

The following specifications will be observed as far as practical in spacing tie trees:

| | Average length of span | Maximum length of span |
|---|---|---|
| | *Feet* | *Feet* |
| 1. In fairly open country where snowfall is not a material factor | 135–150 | 180 |
| 2. In timber and where snowfall is a material factor | 100–125 | 150 |
| 3. Along rights of way and trails, from | 110–115 | 125 |
| 4. At main highway crossings | Width of cleared right of way | |
| 5. At railroad and transmission line crossings | (See fig. 39) | |
| 6. Where snowfall is not a danger factor, across arroyas, canyons, rivers, and choppy topography, especially where timber is scarce (special anchors required for long spans; see fig. 19) | | 1,200 |
| 7. Equalize length of spans as far as possible in order that weight of wire in each span will be about the same. | | |

In instances where trees are not available to make for satisfactory and practical equalization of spans or to keep within the maximum length use poles equipped with split tree insulators in the intervening opening.

### HANGERS AND TIES, ORDINARY

Approved types of hangers and method of making the different ties are shown in Figures 9, 11, 12, and 13. With this method, attach the wire to the tree in such a way that the pull is always away from the tree. Better brush clearance and wire location may be secured at times by using a tie wire several feet long. (See "Height of wire.") In districts 5 and 6 the tree pin or tree hook is used with No. 9 galvanized iron line wire or 18 seizing strand for making ties as shown in Figures 4, 5, 7, and 8. These methods make practical "indrawing ties" proof against "tree ground." At unavoidable sharp angles use the double tie illustrated in Figure 14.

Since the loose tie and slack are the chief essentials of tree-line construction "solid," "stay," or "anchor" ties will not be used merely to "tie" the wire at intervals of distance arbitrarily determined. There must be a sound reason to warrant solid ties, such as, for example:

(1) Solid ties: Where line is run at an abrupt angle up or down a steep slope for distances in excess of a quarter mile.

(2) Dead ends: (*a*) At railroad, highway, and electric transmission line crossings (see fig. 19); (*b*) on each side of spans exceeding maximum specified on page 17; (*c*) at terminals of line; (*d*) at top of abrupt slopes where the strain might be too great for an ordinary solid tie.

Approved stay or solid ties for use on slopes of abrupt angle are shown in figures 15, 16, 17, and 18. Figures 17, 18, and 19 illustrate specifications to be followed in anchoring (dead-ending) lines at terminals at special crossings, tops of abrupt slopes, or at either end of long spans which jump across streams, deep canyons, ravines, etc.

## SLACK

Adequate slack is almost as indispensable to a successful tree line as the line wire itself, since without slack frequent breaks in the line are inevitable.

The impulse of workmen inexperienced in tree-line construction is to "pull" the slack—"to hear her sing." The more experience men have had in pole-line work without adequate subsequent training in tree-line type of construction, the more likely is the evil of tight lines when pole-line men first engage in Forest Service telephone jobs.

This is the rule that should be followed:

*Leave sufficient slack in each span so that the line may be easily pulled to the ground between two hangers.*

"Easily pulled" means that the wire will come down under an applied weight of from 75 to 90 pounds. About 3 or 4 feet of slack is about right for each span ranging in length from 100 to 140 feet. In order to maintain even distribution of slack, spans must be of approximately equal length.

Longer spans will be given more slack. A span of 400 feet should have not less than 10 feet, and one of 1,000 feet should have not less than 20 feet. Spans of intermediate lengths should have slack in due proportion

## CONSTRUCTION IN WOODLAND TYPE

It is sometimes impossible in the woodland type of forest to construct lines in accordance with the standard specifications because trees of suitable size for tie trees are so scattered.

Fortunately, the probability of damage from snow and danger of breakage from windfall in this type of forest is slight. Accordingly, deviations from the standards set up in this handbook can be made usually without material sacrifice to the integrity of a completed line. No definite specifications can be outlined for use under such conditions. The best judgment of the man in charge of construction must govern in the selection and location of tie trees, etc. The following instructions will be followed as general guides:

(1) As far as consistent with economy of maintenance avoid the use of poles.

(2) To the extent possible, tie trees should be selected that will provide for (*a*) as close conformity as possible to the standard height of wire above the ground, (*b*) the standard length of span, (*c*) equality of length of span, (*d*) supporting the wire in a position not directly over the traveled route if there is danger of the wire falling into the traveled way upon failure of a hanger, (*e*) only necessary crossings of the traveled way.

Items (*d*) and (*e*) may be ignored if the line follows a foot trail or a "way."

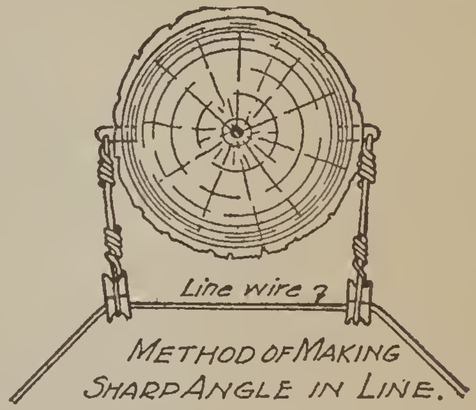


FIG. 14.—Double insulator on angle

## SIZE OF CREWS

Crews composed of three or four men, exclusive of cook, have proved to do the best and most economical work. Four-man crews are advocated even where clearing is heavy.

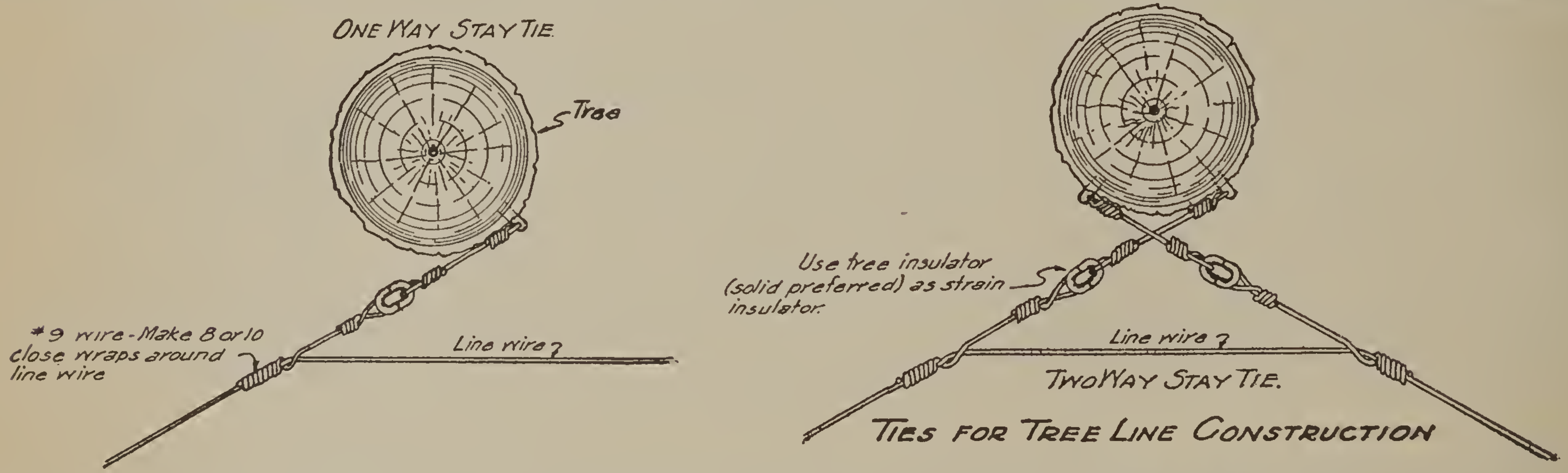
## MARKING OF TIE TREES

It is advisable to locate tie trees before stringing the wire. Designate tie trees by some conspicuous mark, but do not blaze them. Blazing of trees for such purposes is distasteful to a forester. Marks will indicate the side on which the wire is to hang.

Perhaps the simplest method of marking is to lean a stick against the tree, which, as well as indicating tie tree, will also indicate the side on which the wire is to hang.

## STRINGING WIRE

The wire may be strung out by placing the coil upon a reel of simple construction (fig. 20) carried by two men. Straps passing over the shoulder and fastened to the reel handles may be used to relieve the arms and




FIGS. 15 AND 16.—Approved methods for making solid ties for tree-line construction in connection with use of hangers illustrated in Figures 9 and 10

hands. If the line is hung along a road, the reel may be placed in a wagon or truck. The reel may be set stationary and wire from it may be pulled out by a horse or by hand. On some forests reels fitted over the crosstree packsaddle, from which to pay out wire off a pack animal, are commonly used.

Use a reel wherever practical, but in rare instances, when it may not be used to best advantage, the coil may be held as indicated in Figure 21 and wire paid off it. Use care to avoid kinks in the payed-off wire by

throwing off a few turns of wire alternately on opposite sides of the coil to keep out the twist.

In stringing wire over sharp rocks carry the reel. Pulling it will likely scrape off the galvanized coat. Early rust and rapid deterioration will result.

### STANDARD SPLICE IN NOS. 9 AND 12 IRON WIRE

The regular Western Union splice, made with six or seven tight wraps, is standard. (See figs. 22, 23, and 24.) Soldering splices is unnecessary, but take care that the wires are clean before the splice is made and that each turn is tight. Loosely wrapped splices will cause line trouble which is very difficult to locate. In cleaning the wire do not scrape hard enough to injure the galvanized coat.

### HANGERS

If the type of hanger shown in Figure 11 is employed, the strand with thimble should be made up in quantities in advance of actual construction work.

The hangers of Nos. 9 or 12 line wire shown in Figures 9 and 10 can only be made up on the ground as the line hanging progresses.

### ATTACHING INSULATORS

In attaching the hanger wire to insulators take care not to "burn" the wire by twisting it too tightly at the top of the insulator. The tie wire, however, should

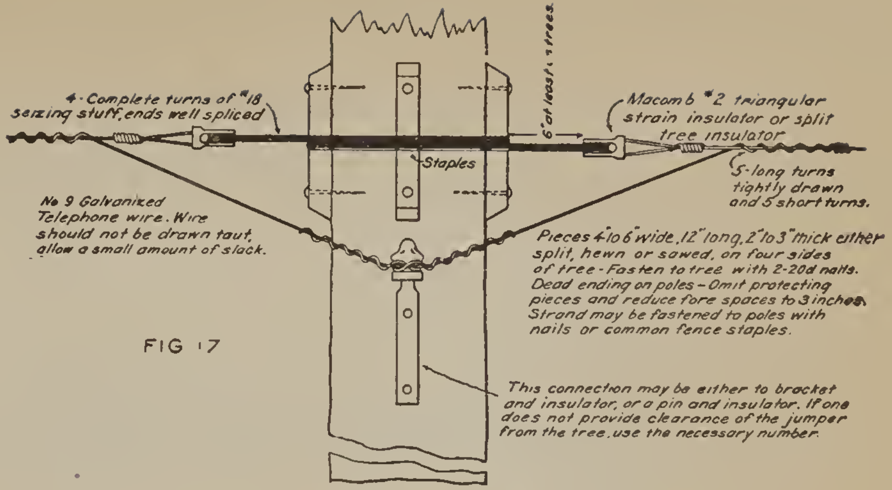



FIG 17

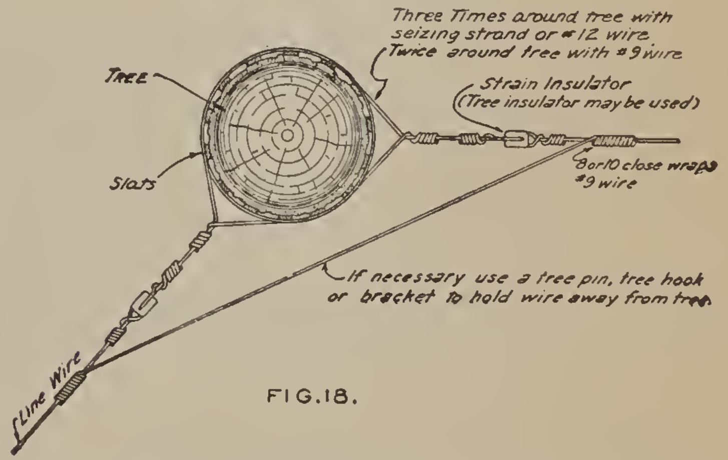



FIG. 18.

FIGS. 17 AND 18.—Approved methods for making solid ties for tree-line construction in connection with use of hangers illustrated in Figures 9 and 10

grip the insulator tightly enough to prevent the insulator from turning in it. See to it that the joint of the insulator is so placed that the line will not rest against it.

## ATTACHING THE HANGERS AND HANGING THE LINE

Use ladders rather than climbers to reach the position of staples, hooks, pins, and rings and to attach the hangers to these supports. Ladders make for faster, more uniform and altogether better work. (Ladders are also better for clearing.) One pair of tree climbers, however, should be on every job. They come in handy for miscellaneous climbing.

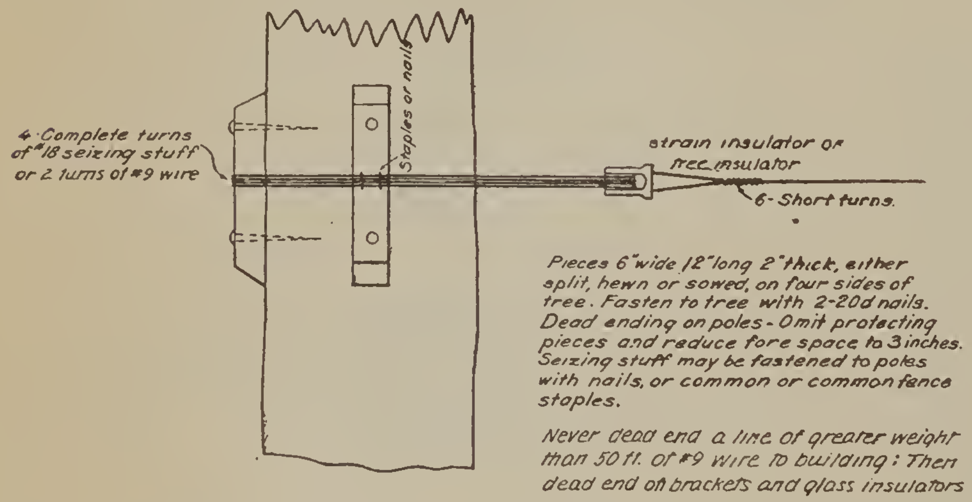


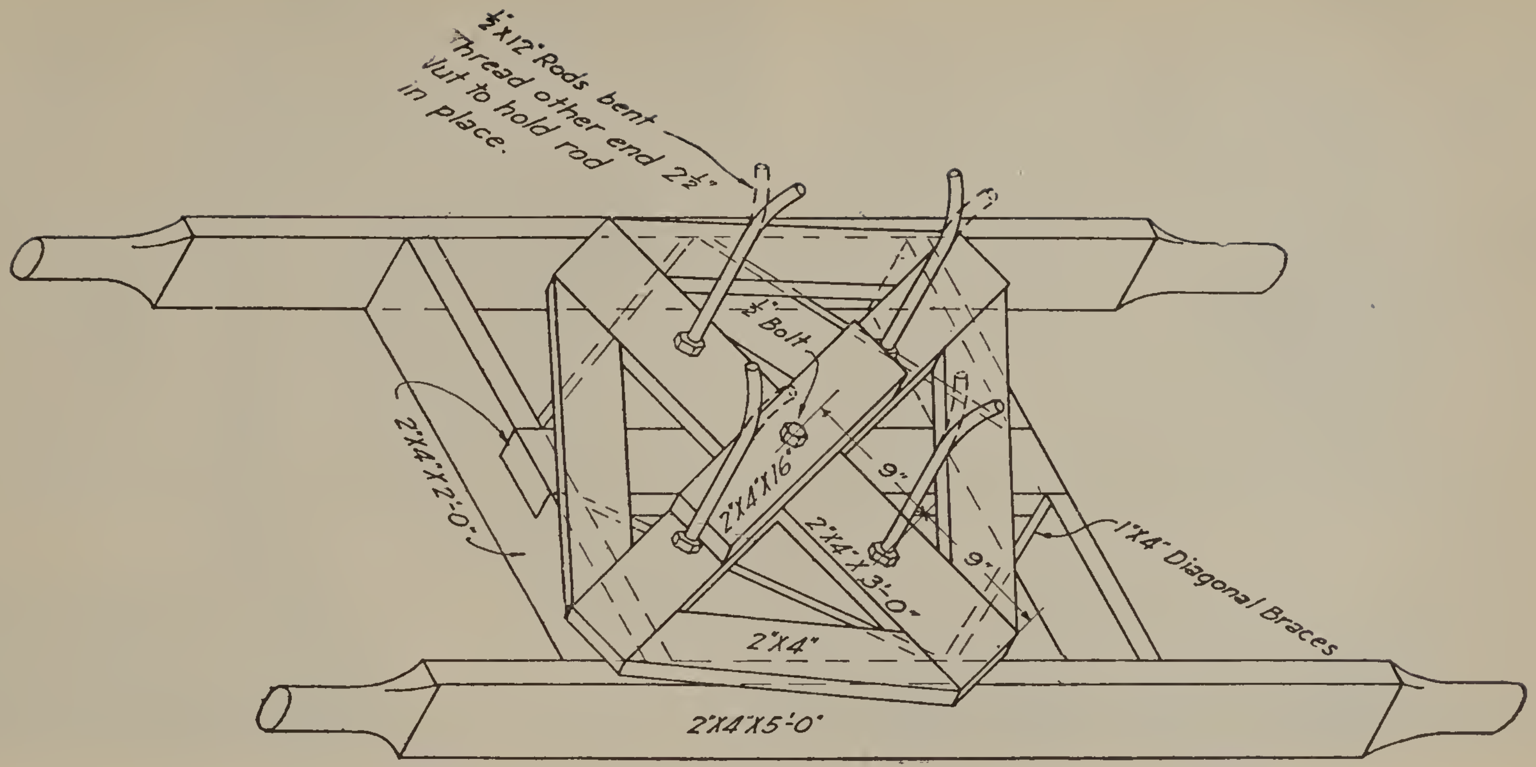

FIG. 19.—Approved method for making solid ties for tree-line construction in connection with use of hangers illustrated in Figures 9 and 10

The methods to be followed in attaching the hangers will depend upon type of hanger support used. Refer to Figures 2 to 5 and 7 to 14. Follow the specification therein illustrated for the particular type selected. For all ordinary ties, unless a district forester instructs otherwise, the standard bright or galvanized staple will be used to attach the hanger to the tree unless a stronger form of anchor may be needed for dead ending (figs. 17, 18, and 19) or in making attachment by use of a ring of wire to small tree or large limbs (fig. 2). If the ring is used, attach the hanger to it as illustrated.

With an ax or hatchet smooth off rough bark before driving hooks or staples, but do not cut into the sap, as it may run and cause a "ground."

## PULLING SLACK

Do not use blocks and tackle to pull slack. They are entirely unnecessary, except in pulling long spans across inaccessible places. "Tight lines" can be charged to the use of blocks oftener than to any other cause. Pull up slack by hand at intervals of every sixth or eighth tie, or more frequently. Have someone behind to see that it is up in proper position, that it has plenty of slack (see "Slack"), and that it is hanging free of all obstacles



$\frac{1}{2}$"X12" Rods bent
Thread other end $2\frac{1}{2}$"
Nut to hold rod
in place.
$\frac{1}{2}$" Bolt
2"X4"X2'-0"
2"X4"X16"
9"
9"
2"X4"X3'-0"
1"X4" Diagonal Braces
2"X4"
2"X4"X5'-0"


FIG. 20.—Reel

FIG. 21.—Paying out the line wire by hand

that may, when removed, call for radical readjustment of the line wire. Hold each pull by the simple device of hitching the wire directly to a limb, tree, or root, or with a lineman's grip and rope; fix the grip on the wire, and tie the rope to some stable object.

FIG. 22.—Splicing. Starting second half of splice, showing connectors in proper position

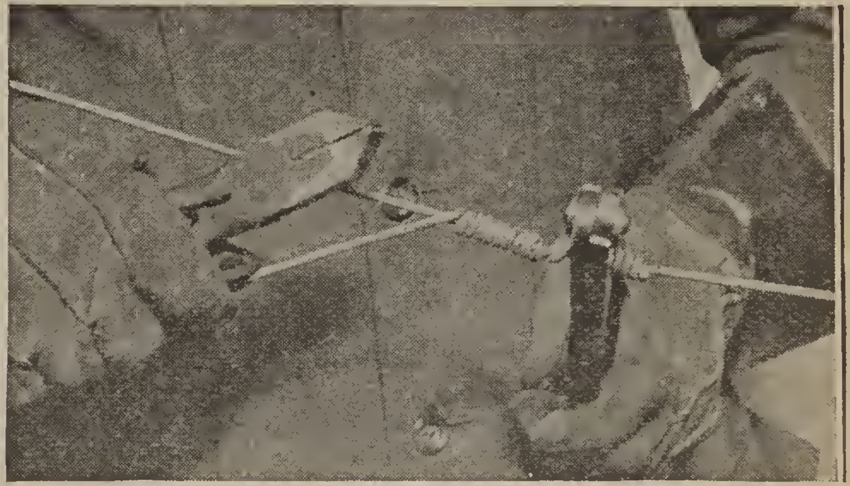


FIG. 23.—Splicing. Wraps completed. Make nick in end; break it off close to line wire

### SOLID TIES, ANCHORS, AND DEAD ENDS, WHERE APPLICABLE

Never in lines except as indicated on pages 18.

### FINAL CLEARING

With a given section of the line in final and proper position send a man back over it for the purpose of removing all branches, etc., in order to insure that the clearing specifications are completely met.

# CONSTRUCTION, POLE LINES

## SPECIFICATIONS, WHERE AND EXTENT APPLICABLE

The following specifications and instructions will be used for the construction of pole lines, except where, on account of peculiarity of conditions, it is impractical to secure pole and crossarm material of appropriate species and dimensions. In this event poles, crossarms, etc., of other species or of similar dimensions, or tripods (where livestock damage is not likely) of suitable construction may be substituted upon approval of the district forester, provided that small poles will be of sufficient strength and will be long enough to give 12 feet of clearance above the ground for the lowest line wire. Material having a life in the ground of less than five years should not be used.

## HEIGHT OF POLES

The average pole line of the Forest Service is much simpler mechanically than the regulation lines of the commercial companies. A greater part of the mileage of the pole lines of the Forest Service carry but one wire and at the most two. There are lines in the Forest Service system which, to be sure, approach the problems encountered in commercial practices and where commercial specifications are in keeping with the situation; but these are exceptions. Accordingly specifications for Forest Service pole lines can call, and should call, for lighter construction as a general rule than those applicable in commercial line construction with no unwarranted sacrifice of permanence. The pole and stub specifications contained in the following tables are worked out on this principle.


FIG. 24.—Completed splice

In deciding upon the height of pole to use the rule should be: Select a pole of such height as will give the lowest wire ample clearance to insure against damage from passing livestock and traffic. Again, as a general rule, this clearance should correspond to the minimum specified for tree lines—12 feet—except at road crossings, where poles will be high enough to give the lowest wire a 3-foot margin of clearance above the highest anticipated passing object, such as high loads of wood. steam tractors, loads of hay, etc.

## POLES, SPECIFICATIONS

White cedar, Port Orford cedar, western incense cedar, juniper, chestnut, or redwood poles, conforming to the following specifications and dimensions, will be used if their cost is within the limits of reason. If not, use

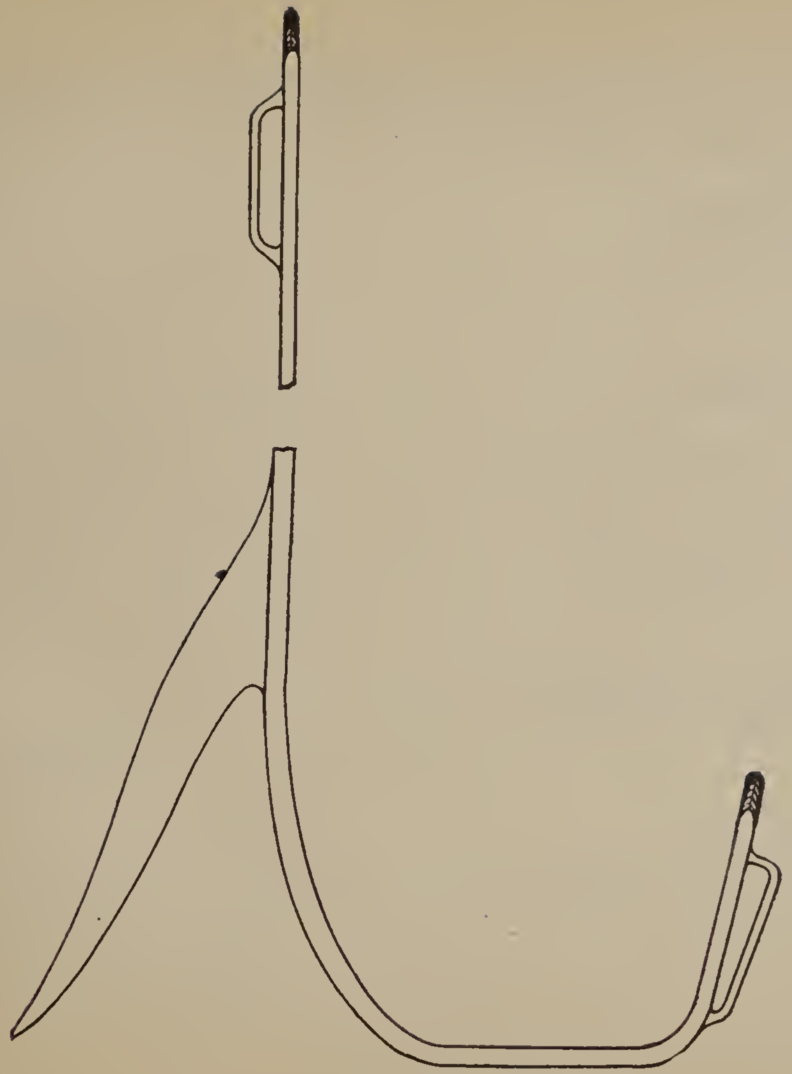


Fig. 25.—Special tree climbers. (Not well suited for use in climbing poles)

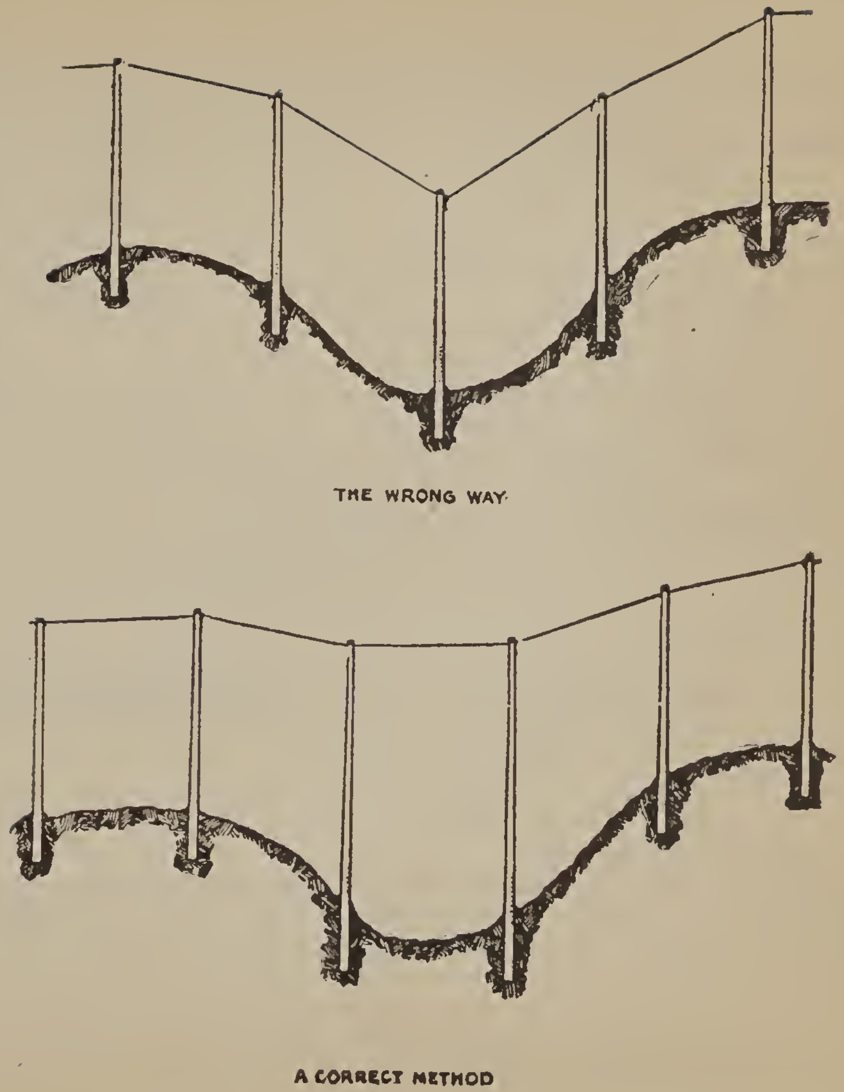



Fig. 26.—Setting poles to fit ground contour

45525°—25†——3

poles of other species having sufficient strength and length, attached either to treated stubs of nonresistant species or untreated stubs of the favored species named in the following tabulation. If poles and stubs are used, do not bury the poles. Fix poles to the stubs as indicated in Figure 27.

*Pole and stub dimensions*

UNSTUBBED POLES (ROUND)

| Species | Character of service | Length | Minimum diameter | |
|---|---|---|---|---|
| | | | Top | Butt |
| | | *Feet* | *Inches* | *Inches* |
| Cedar, chestnut, or locust | Regular use | 18 | 5 | 8 or 9 |
| Do | Special purpose | 25 | 6 | 9 |
| | | 30 | 6 | 10 |
| | | 35 | 6 | 11 |
| | | 40 | 7 | 13 |

UNSTUBBED POLES (SAWED OR SPLIT)

| Species | Character of service | Length | Minimum cross section | |
|---|---|---|---|---|
| | | | Top | Butt |
| | | *Feet* | *Inches* | *Inches* |
| Redwood<br>Cedar | Heavy duty (3 or more metallic lines, 6 wires) | [1] 18–20 | 4 by 4 | [1] 8 by 8 |
| Redwood<br>Cedar | Ordinary duty (2 or less metallic lines, 4 wires) | 18–20 | 4 by 6 | 4 by 6 |

[1] In case a longer pole for special purpose is required, be guided as to its proper dimensions by table at top of page.

*Pole and stub dimensions*—Continued

STUBBED POLES (ROUND)

| Species | Character of service | Length | Minimum diameter | |
|---|---|---|---|---|
| | | | Top | Butt |
| | | *Feet* | *Inches* | *Inches* |
| Strongest reasonably available | All, except at crossings where a longer pole is required | 14–16 | 6 | 8 or 9 |

STUBBED POLES (SAWED OR SPLIT)

| Species | Character of service | Length[1] | Minimum cross section | |
|---|---|---|---|---|
| | | | Top | Bottom |
| | | *Feet* | *Inches* | *Inches* |
| Strongest reasonably available | Heavy duty (3 or more metallic lines, 6 wires) | 14–16 | 4 x 4 | 8 x 8 |
| Do | Ordinary duty (2 or less metallic lines, 4 wires) | 14–16 | 4 x 6 | 4 x 6 |

[1] Longer poles may be necessary at right-of-way crossings.

*Pole and stub dimensions*—Continued

UNTREATED STUBS (ROUND)

| Species | Length | Minimum diameter | |
|---|---|---|---|
| | | Top | Butt |
| | *Feet* | *Inches* | *Inches* |
| Western red cedar, round | 8 | 11 | 12 |
| Yew | 8 | 8 | 8 |
| Chestnut | 8 | 8 | 8 |
| Juniper | 8 | 5 | 6 |
| Locust | 8 | 5 | 5 |
| Post oak | 8 | 5 | 5 |
| White oak | 8 | 5 | 5 |

UNTREATED STUBS (SAWED OR SPLIT)

| Species | Length | Minimum cross section | |
|---|---|---|---|
| | | Top | Butt |
| | *Feet* | *Inches* | *Inches* |
| Western red-heart cedar | 8 | 8 by 8 | 8 by 8 |
| Port Orford cedar | 8 | 8 by 8 | 8 by 8 |
| Redwood, square | 8 | 8 by 8 | 8 by 8 |
| Pines, pitch impregnated | 8 | 8 by 8 | 8 by 8 |
| White oak | 8 | 6 by 6 | 6 by 6 |

TREATED STUBS (ROUND, OPEN-TANK METHOD [1])

| Species | Length | Minimum diameter | |
|---|---|---|---|
| | | Top | Butt |
| | *Feet* | *Inches* | *Inches* |
| Lodgepole | 8 | 8 | 8 |
| Tamarack | 8 | 8 | 8 |
| Firs | 8 | 8 | 8 |
| Western yellow pine | 8 | 8 | 8 |
| Douglas fir | 8 | 8 | 8 |
| Western red cedar | 8 | 8 | 8 |
| Spruce | 8 | 8 | 8 |

[1] See "Creoseote tratment, open-tank method."

## ROOF

The top of each pole shall be roofed. Where crossarms are used or are contemplated, the ridge of the roof shall run parallel to the line wires, but when only brackets are used or will in the future be used make the ridge of roof at right angles to the line wires.

## USE OF BRACKETS

On poles carrying not more than four wires (two metallic circuits) the regular wood brackets and insulators will be used with spacing of 15 inches as shown in Figure 27. Fasten brackets on base with bracket clip. (Fig. 28.)

## USE OF CROSSARMS, PINS, AND INSULATORS

Poles carrying more than four wires will be fitted with standard crossarms. (See fig. 27, showing a six-pin arm attached.)

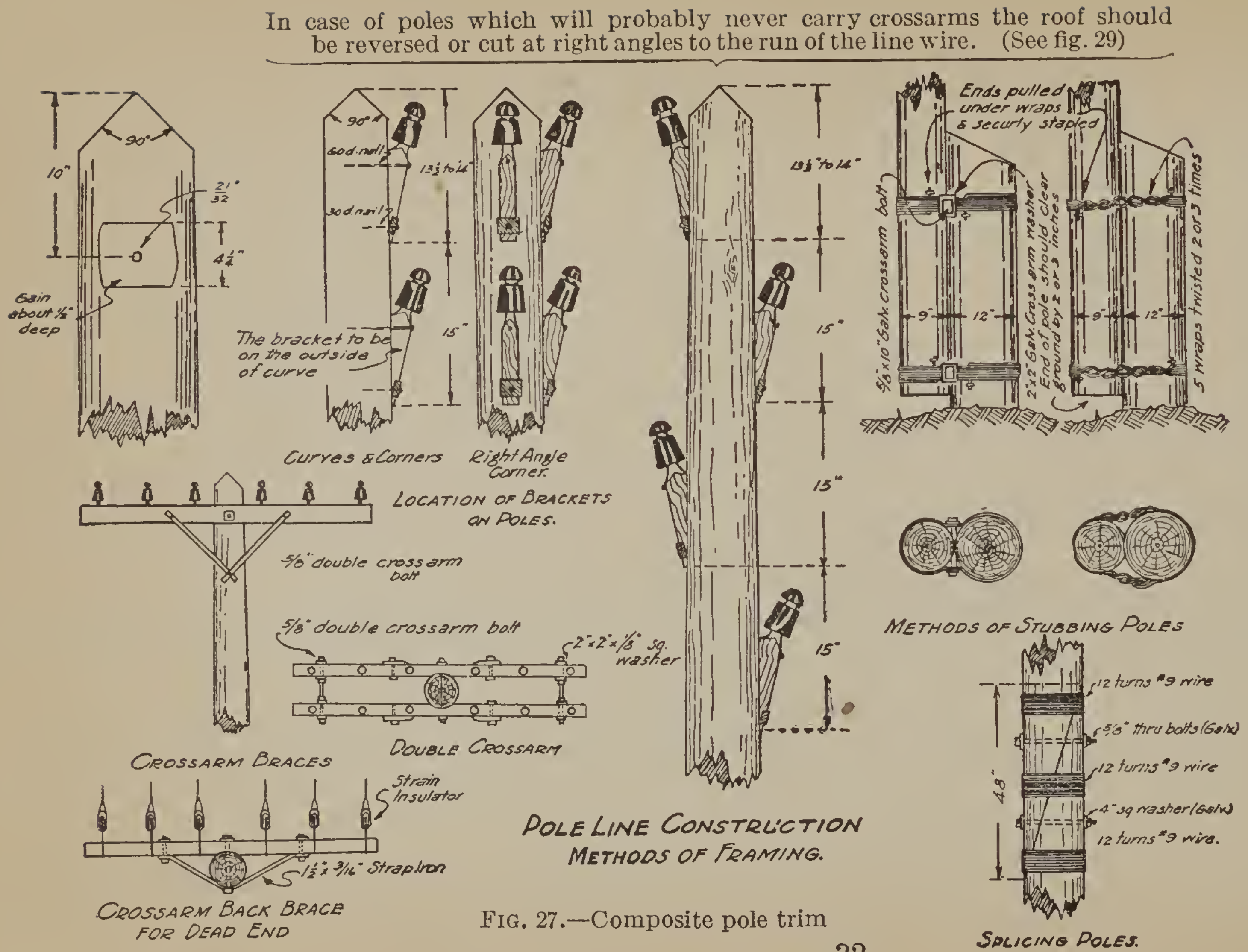



FIG. 27.—Composite pole trim

Crossarms should be the standard 3¼ by 4¼ inch arm, and long enough for the desired number of pins. Holes for pins shall be ½ inch in diameter, spaced as follows:

16 inches between the two center holes (each hole 8 inches from center of crossarm).

12 inches between holes on each side of center holes.

4 inches between outside hole and end of crossarm.

Each crossarm shall also have one hole 21/32 inch in diameter, bored at the center for a ⅝-inch crossarm bolt and two ⅜-inch holes spaced 17 inches each side of the center for brace bolts.

The regular ½ by 9¼ inch Western Union steel pin will be used.

Use the standard 16-ounce pony glass insulator.

## FRAMING FOR CROSSARMS

Gain to be cut 4¼ inches wide and about ½ inch deep, the center of the top gain to be 10 inches below the apex of the roof. (See fig. 27.) Additional gains to be cut 24 inches apart, center to center. A hole $\frac{21}{32}$ inch in diameter shall be bored through pole at center of each gain for a ⅝-inch bolt. All gains and pole tops to be given one coat of creosote.

## ATTACHING CROSSARMS

Each crossarm will be attached to the pole with one ⅝-inch bolt and two crossarm braces. The bolt shall be long enough to go through the pole and crossarm without cutting out the back of the pole. The bolt shall be driven through from the back of the pole, a 2-inch square washer to be under both the head and the nut. Two 24-inch braces to be attached to each crossarm by means of ⅜-inch carriage bolts and attached to the pole with one ⅜ by 4-inch lag screw.

## FACING OF CROSSARMS

On straight stretches crossarms on adjacent poles face in opposite directions. At long spans put crossarms on side of pole away from the span, and at highway crossings on road side of poles. On curves face crossarms to center of curve. The crossarm on the

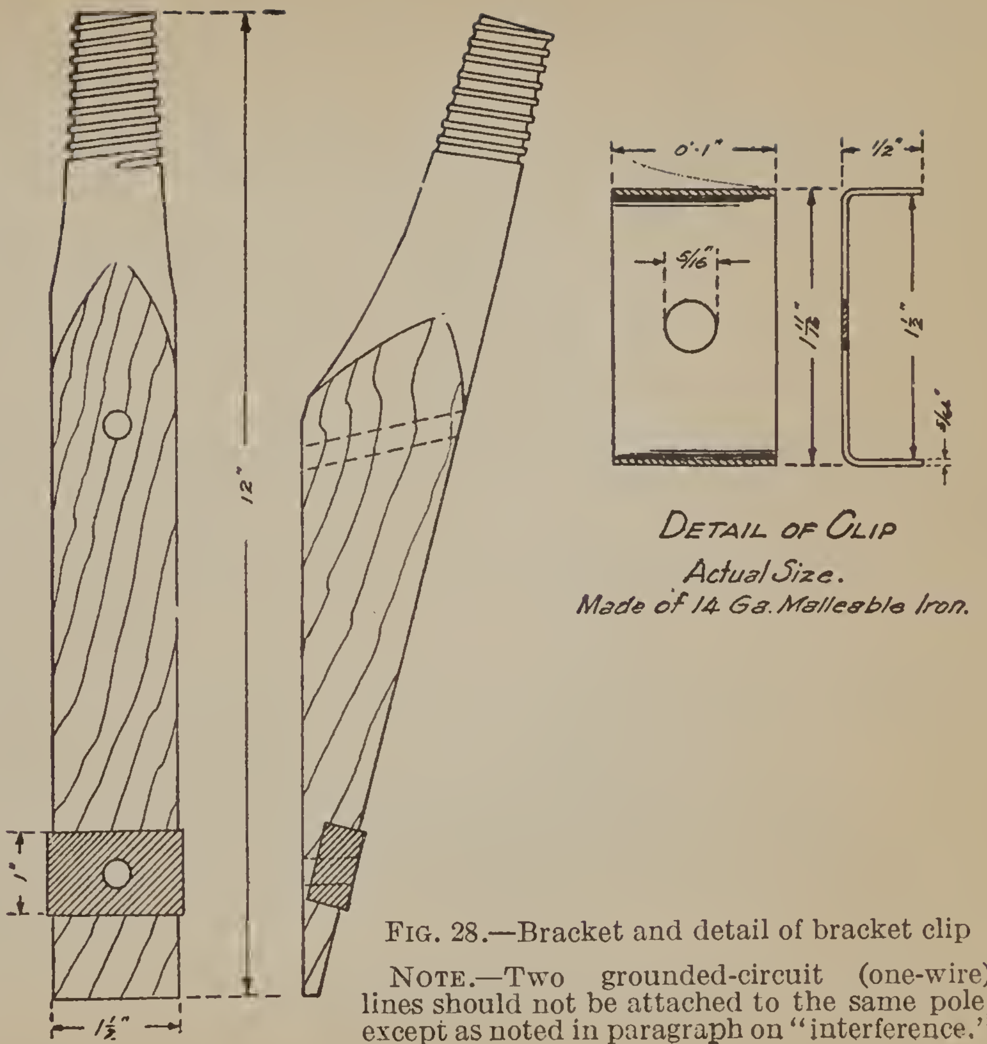



Fig. 28.—Bracket and detail of bracket clip

Note.—Two grounded-circuit (one-wire) lines should not be attached to the same pole, except as noted in paragraph on "interference."

last pole should be fitted with back braces and the line wires dead-ended with strain insulators, as shown in Figure 35 (or double-armed). The crossarm on the pole next to the end pole should face the end.

## SPAN LENGTHS

On straightaways, poles shall be set approximately 35 to the mile; on curves, corners, or at line terminals span lengths to be according to the following table (see diameter or "pull" in fig. 31):

| Amount of pull (feet) | Span length (feet) |
|---|---|
| 5 to 15 | 125 |
| 15 to 20 | 120 |
| 20 to 25 | 115 |
| 25 and over | 100 |

At line terminals, the last span should not be over 100 feet long. The first span on each side of a long span (250 feet or over) should be 100 feet long.

## DISTRIBUTION OF POLES

The heaviest poles should be placed at corners, line terminals, and at ends of long spans.

## DEPTH OF HOLES

Where the pole or stub is set in a sloping bank, measure depth of hole from lower side of hole. Poles shall be set to depths as follows:

18 to 25 foot pole set 4 feet deep in dirt, 3 feet in solid rock.
30 foot pole set 5 feet deep in dirt, 3½ feet in solid rock.
35 foot pole set 5½ feet deep in dirt, 4 feet in solid rock.
40 foot pole set 6 feet deep in dirt, 4½ feet in solid rock.

## SIZE OF HOLES

All pole holes shall be dug large enough to admit pole or stub without hewing and large enough at bottom to allow use of tamping bar on all sides.

## RAKE

Poles on corners or curves should be raked as follows: Where "pull" (see fig. 31) is less than 5 feet, the rake should be about 10 inches; 5 to 10 foot pull, rake about 15 inches; over 10-foot pull, rake about 25 inches.

## FILLING AND TAMPING

After pole is set in hole, fill and tamp, preferably using only one shoveler to three tampers, who shall work continuously until hole is filled.

## BRACING AND GUYING

The use of braces and guys is obviated in many cases by a proper amount of rake, but either bracing or guying will be necessary in the following cases:

(*a*) On any pole on a curve or at corner where the pull exceeds 30 feet.

(*b*) On poles at each side of a crossing over roads and railroad rights of way.

(*c*) On the two end poles of spans between 300 and 500 feet.

(*d*) On the poles at either end of spans above 500 feet.

(*e*) On very steep slopes. Anchor guys may preferably be used in these cases, or a head guy from the top of one pole (below the lowest bracket) to the base of the pole next above it.

(*f*) On alternate poles in exposed positions.

(*g*) On poles in swamps or on loose ground (where necessary).

(*h*) On poles on both ends of high-tension transmission line crossings.

(*i*) On the first and last poles of a line.

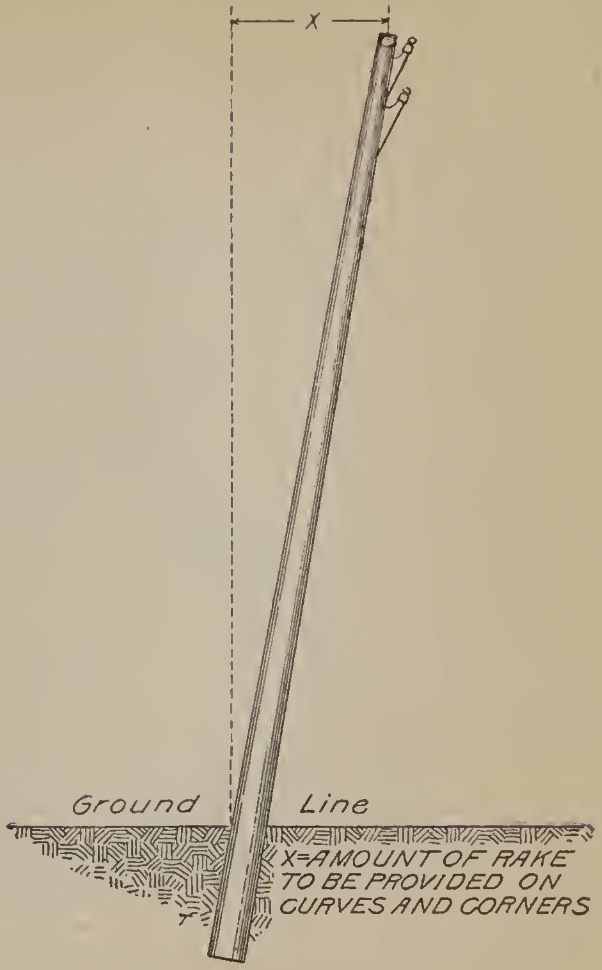



FIG. 29.—Rake of poles

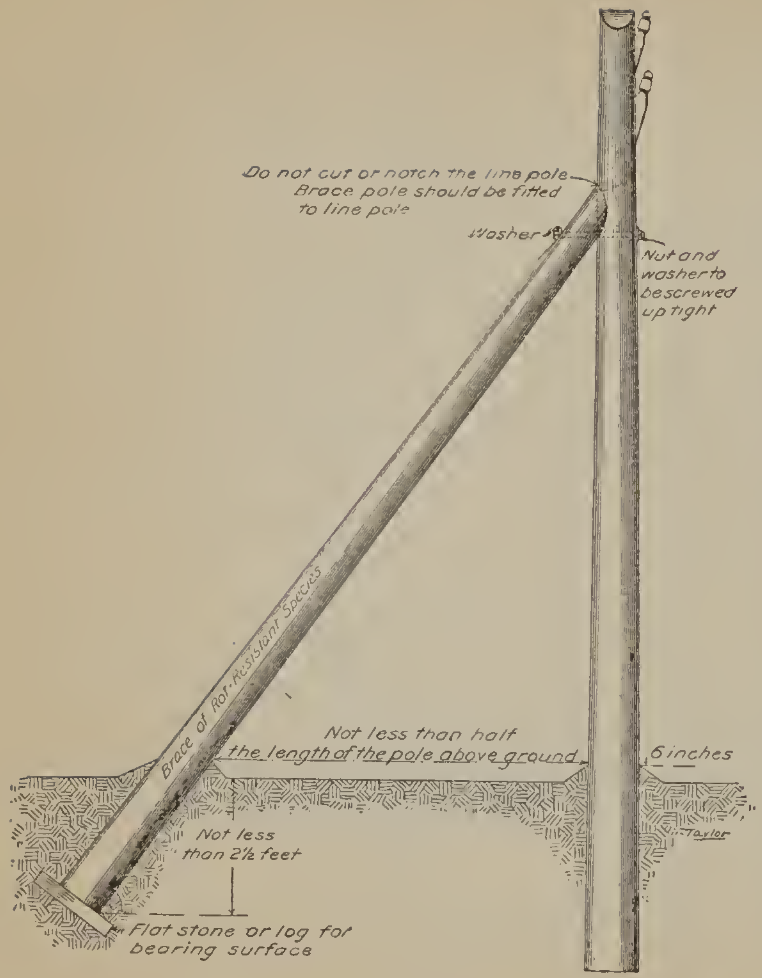



FIG. 30.—Method of bracing

## BRACES

Braces (fig. 30) should be at least 8 inches in diameter at the butt end, cut slanting at the top to fit close to the pole, but the pole itself should not be cut. They should be set at least 2½ feet in the ground; 3½ feet would be better, if too much difficulty is not encountered in digging. The distance between the brace and the pole, as measured on the ground, should be not less than one-half of the height of the pole above ground. The bottom end of the brace should rest on a flat stone or piece of log or plank. After boring a ⅝-inch hole through both the brace and the pole just above the point where the bottom edge of the former touches the latter the brace should be bolted tightly to the pole with a ⅝-inch galvanized-iron bolt, using a 2¼ by 2½ by $\frac{3}{16}$ inch galvanized-iron square washer under both the head of the bolt and the nut.

## GUYS

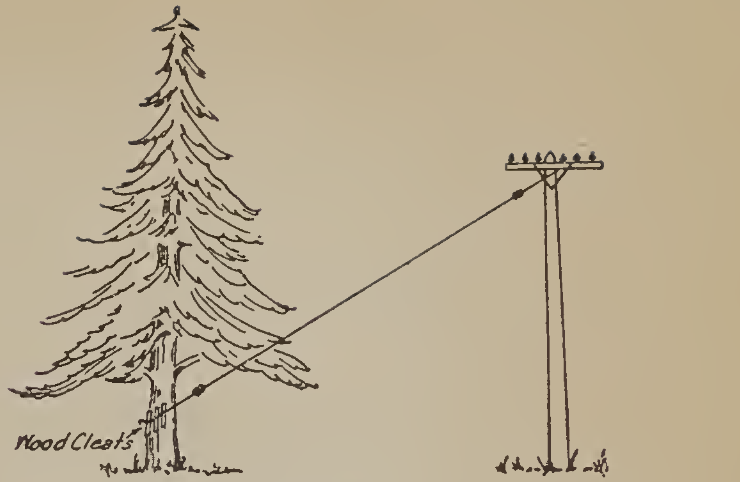
Anchor guys (fig. 32) should be made of two pieces of line wire or four pieces of wire (No. 12) twisted together, and if possible of sufficient length to reach from the bottom of the lowest bracket to a point on the ground at a distance from the bottom of the pole equal to the latter's height above ground, but under no condition less than 6 feet, with enough additional length to allow one end to be passed through the eye of a standard half-inch galvanized-iron guy rod, the other to be wrapped twice around the pole, and both secured.

When a guy has been prepared, one end should be wrapped around the pole twice and stapled, the loose end being secured by wrapping not less than six times around the wire, using a pair of connectors or pliers. Guy to self-expanding guy rods if possible. If not, an anchor log should be placed in the ground with a guy rod passing through it, the eye of the rod projecting above the ground. One of a pair of pulley blocks should then be hooked into the eye and the other fastened to a grip or a medium-sized clamp attached to the guy wire. The latter should then be pulled to the required tension and the end looped through the eye and secured by not less than six wraps, after which the pulley blocks and grip can be removed.

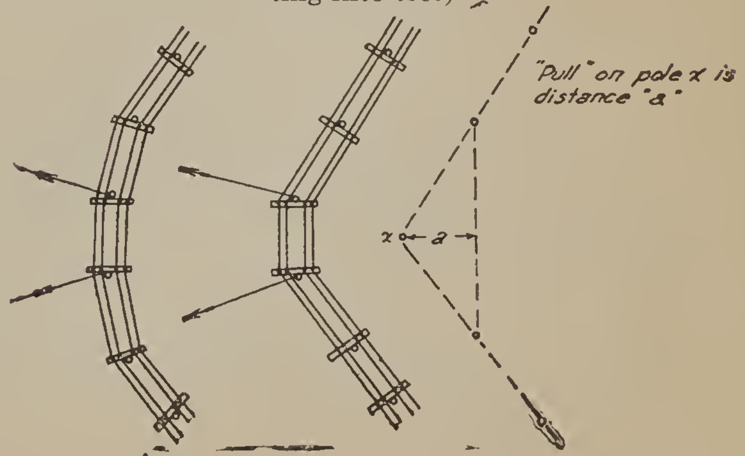
The size of the anchor log will usually be determined by its depth below ground, as follows:

| Depth of excavation | Dimension of anchor log | |
|---|---|---|
| | Length | Diameter |
| *Feet* | *Feet* | *Inches* |
| 4½ | 4 | 6 |
| 3½ | 5 or 7 | 8 or 6 |

If guy rods are not available, the guy wire should be wrapped around the anchor log. This is temporary construction, as the guy wire will rust and break.




Guying to tree. (Use wood cleats to prevent cutting into tree)




Methods of guying and pole location and facing crossarms

FIG. 31.—Methods of guying

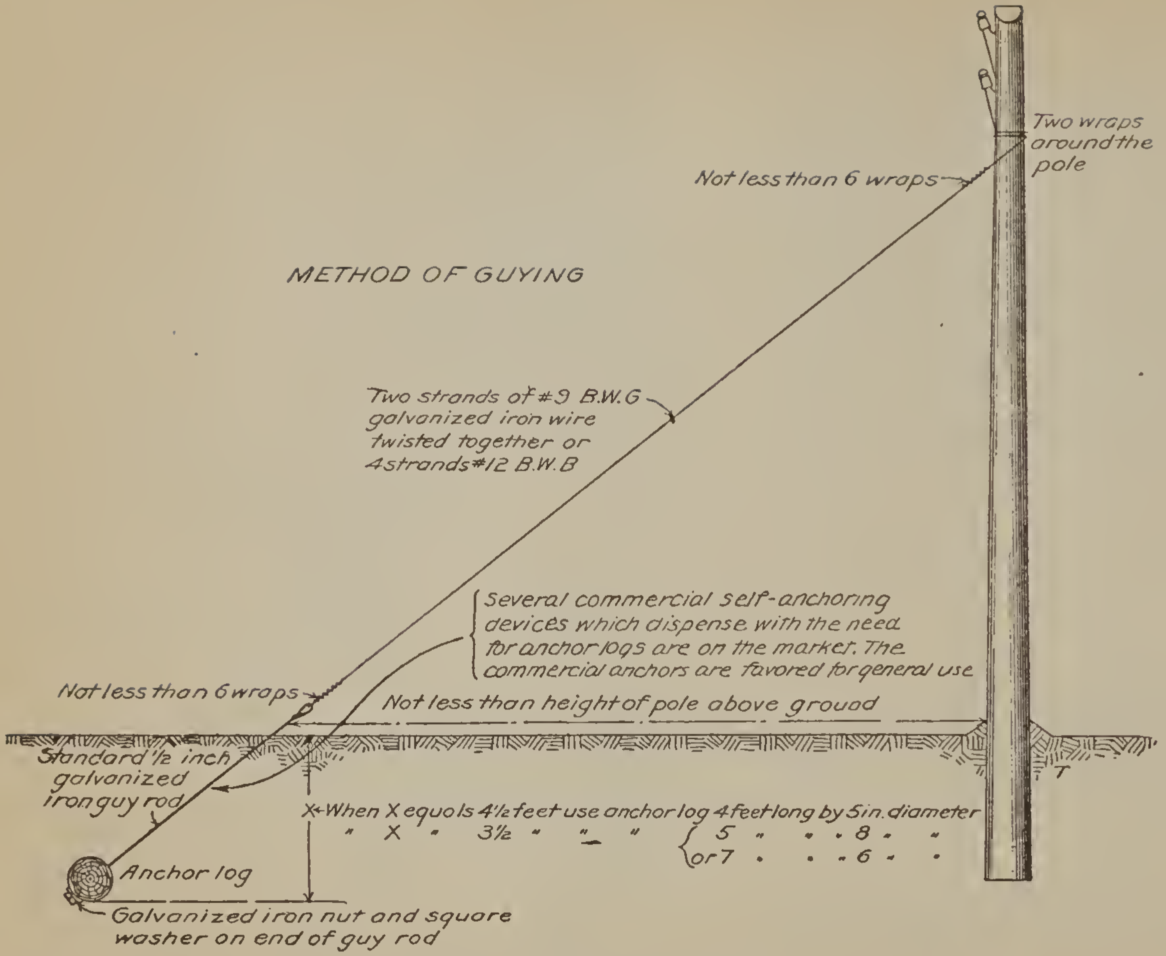



FIG. 32.—Method of guying

When a guy is used on a public highway or street in a city or town, a guard should be used to make it readily visible. For this purpose it may be boxed up to a height of 6 feet above the ground, or a sapling about 3 inches in diameter may be wired to it.

**Tree Guys.**

If there is a live tree of large diameter near by, the guy wire will be fastened to it instead of to a buried log. Hardwood slats should be used between the guy wire and the tree to prevent injury to the latter. (See fig. 31.)

**Rock Guys.**

A homemade iron eyebolt 1 inch in diameter and not less than 18 inches long may be used for anchoring a guy wire in rock. The angle formed by the guy wire and the shank of the bolt should not be more than a right angle. The bolt should not be near the edge of the rock or ledge.

**Guying Across Roads.**

If a guy wire as ordinarily placed would interfere with traffic on a road, a stub should be used (fig. 33) to provide

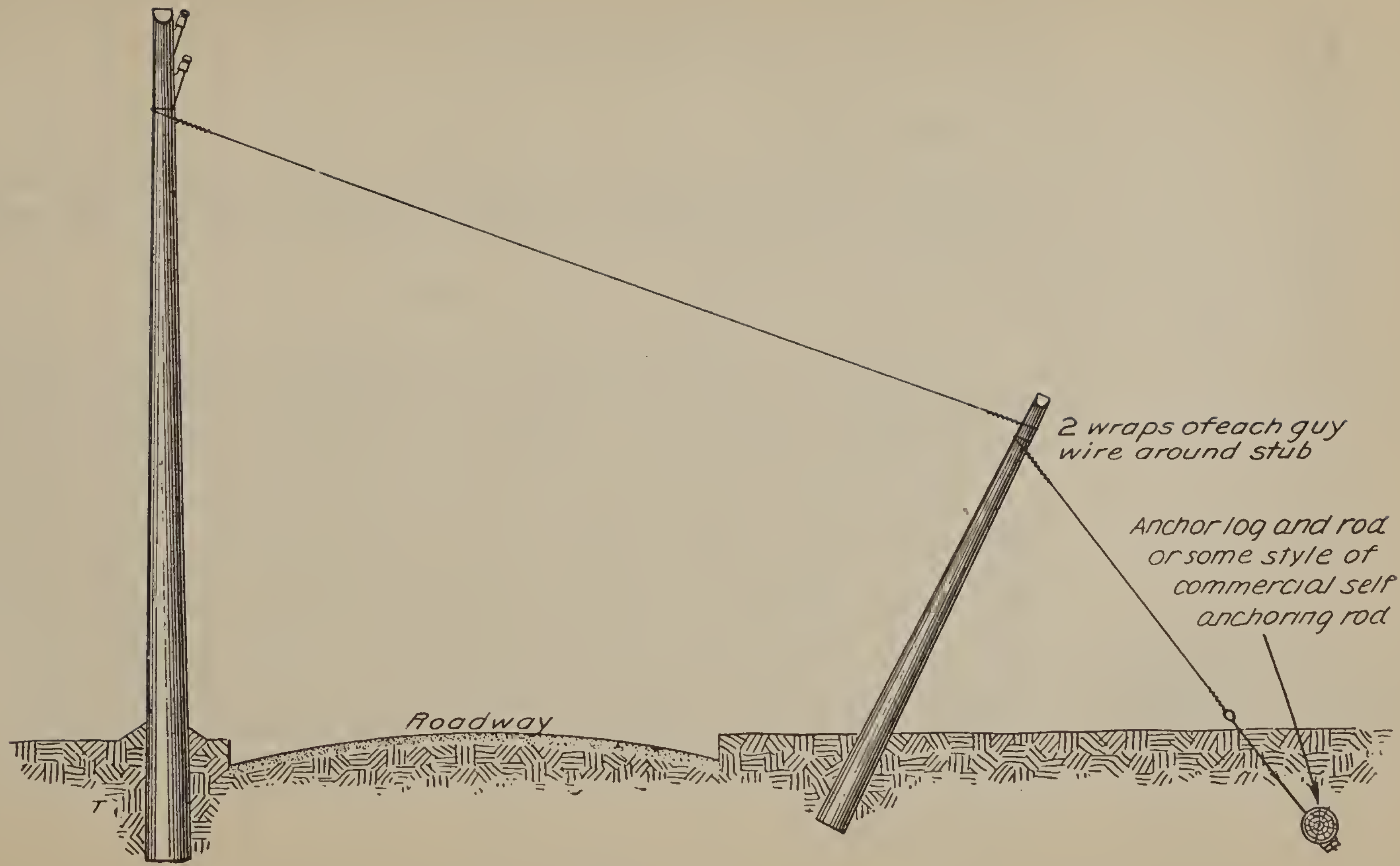
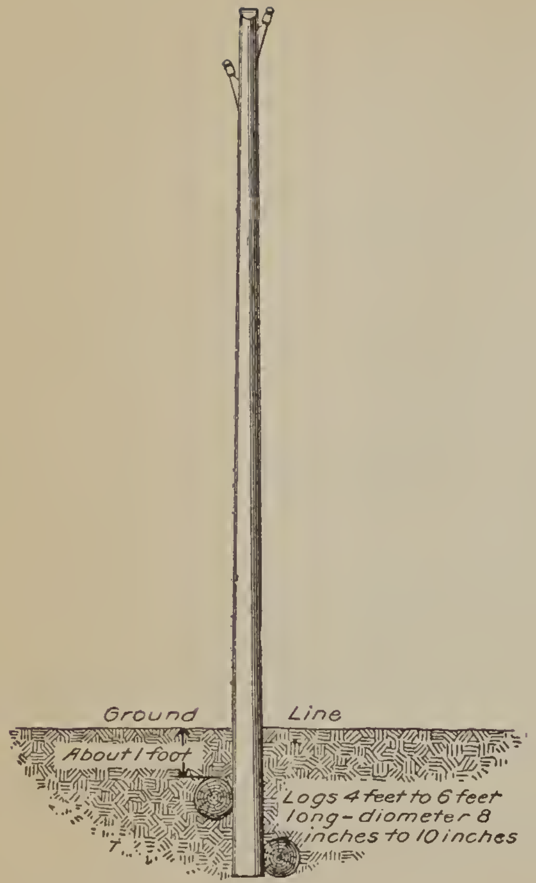



FIG. 33.—Method of guying across road




*This method of ground bracing may be used for poles in swampy soil. Also for poles or guy stubs when not possible to anchor them.*

FIG. 34.—Self-supporting pole

proper clearance. The stub should be stayed with the standard guy rod and anchor log, or if this is not possible braced with anchor logs underground, as shown for the pole in Figure 34.

#### Self-supporting Poles

Where conditions prevent the use of any other method of guying, and especially in swampy soil, the poles should be braced with anchor logs, as illustrated in Figure 34.

### SAG

The stresses in the telephone wire undergo changes with variations in temperature, thus making it necessary to provide for the extreme variations in wire length in each span. The sag in the wire at the time it is made fast to the brackets should correspond to the temperature at that time.

After a half-mile reel of wire has been pulled out, linemen, who follow, carry the wire up each pole on their shoulders and place it between the bracket and the pole. When this has been done over the entire half mile, the line is stretched by means of a Buffalo grip and stretcher block until it is taut, or until the two or three linemen who are on the poles along the half mile stretch pass along the signal to stop. About two minutes' rest is then required for the line wire to "creep" along the entire distance. It should then be loosened or stretched tighter, according to the signals of the men on the poles, who can sight from the bracket of one pole to the brackets of the adjacent poles and determine when the proper amount of slack has been provided.

*Sag of a No. 9 B. W. G. galvanized-iron wire in a pole line*

(Temperatures in degrees Fahrenheit)

| Length of span (feet) | Sag at— | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | +100° | | +80° | | +60° | | +30° | | +10° | | −10° | | −30° | |
| | *Ft.* | *in.* | *Ft.* | *in.* | *Ft.* | *in.* | *Ft.* | *in.* | *Ft.* | *in.* | *Ft.* | *in.* | *Ft.* | *in.* |
| 75 | | 4½ | | 3 | | 2½ | | 2 | | 1½ | | 1½ | | 1 |
| 100 | | 7 | | 5½ | | 4½ | | 3½ | | 3 | | 2½ | | 2 |
| 115 | | 9 | | 7 | | 5½ | | 4 | | 3½ | | 3 | | 2½ |
| 130 | | 11 | | 8½ | | 7 | | 5½ | | 4½ | | 4 | | 3½ |
| 150 | 1 | 2 | | 11½ | | 9 | | 7 | | 6 | | 5 | | 4½ |
| 176 | 1 | 6 | 1 | 3 | 1 | 0 | | 9½ | | 8 | | 7 | | 6 |
| 200 | 1 | 10½ | 1 | 7 | 1 | 4 | 1 | 0 | | 10½ | | 9 | | 8 |
| 260 | 3 | 3½ | 2 | 10 | 2 | 5½ | 1 | 11 | 1 | 8 | 1 | 5½ | 1 | 3 |
| 300 | 4 | 7 | 4 | 1 | 3 | 6½ | 2 | 9 | 2 | 5½ | 2 | 1½ | 1 | 10 |
| 350 | 6 | 6 | 5 | 6 | 4 | 11 | 3 | 10 | 3 | 5 | 3 | 0 | 2 | 7 |
| 400 | 8 | 0 | 7 | 0 | 6 | 6 | 5 | 0 | 4 | 6½ | 4 | ½ | 3 | 7 |
| 450 | 10 | 0 | 9 | 0 | 8 | 0 | 6 | 6 | 6 | 0 | 5 | 6 | 5 | 0 |
| 500 | 12 | 6 | 11 | 0 | 9 | 6 | 8 | 0 | 7 | 6 | 7 | 0 | 6 | 0 |

NOTE.—If a strong wind is blowing, the sag value should be increased. Interpolate for temperatures and spans not given. When any size other than a No. 9 B. W. G. wire is used, it will be necessary to compute the sag required. Instructions for doing this will be furnished by the district office.

## TIES

Make Western Union tie as shown in Figure 35. The tie wire may be the same size as the line wire, or it may be made of No. 12 galvanized-iron wire if desired. Care should be taken to leave the ends of the tie wire long as shown in Figure 35. This facilitates removing the tie. Make dead ends as shown in Figure 35.

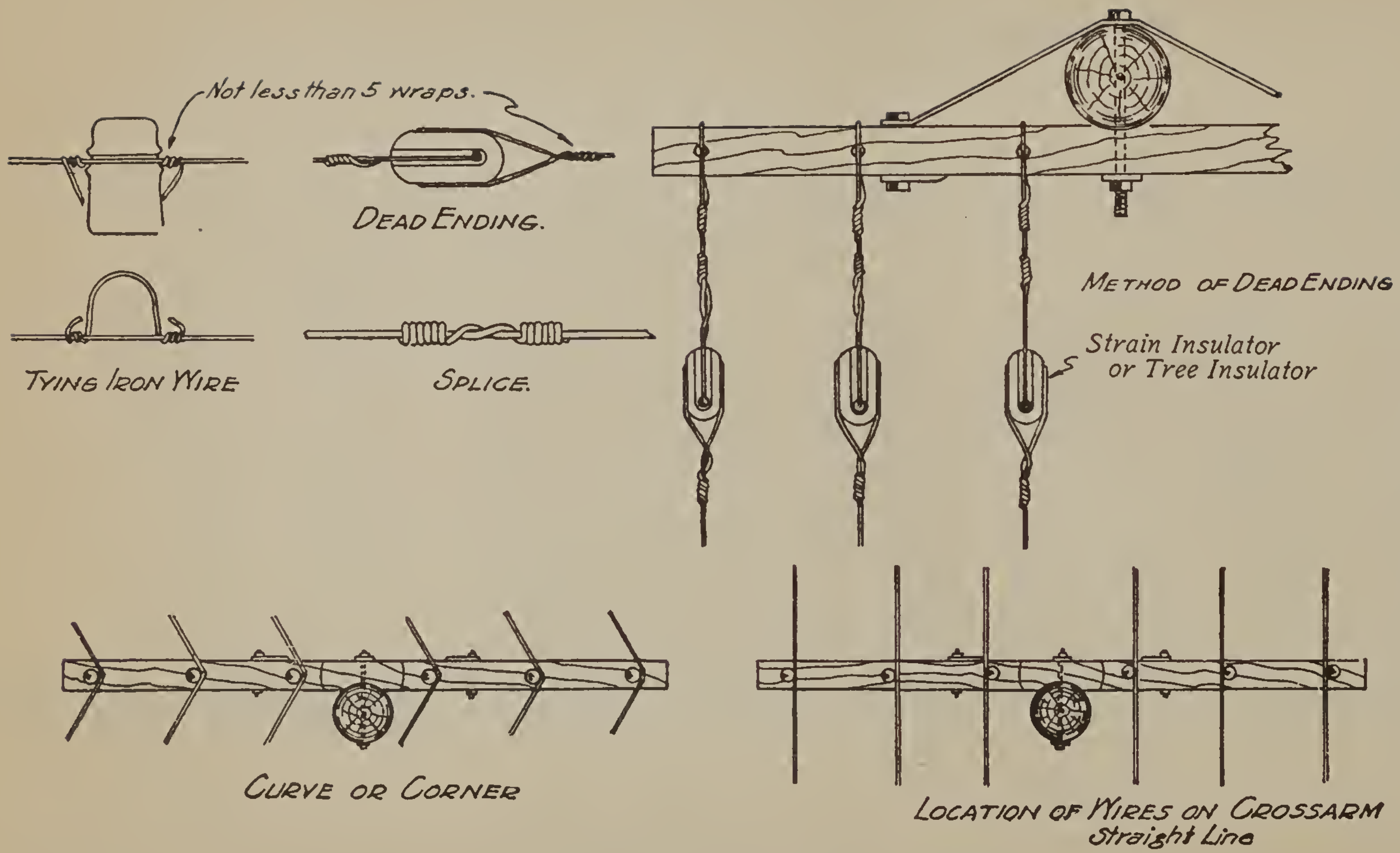



Fig. 35.—Dead ending, tying, and splicing

## LIGHTNING CONDUCTORS

Put a lightning conductor on at least every tenth pole in a lightning country. Use one strand of No. 9 galvanized-iron wire or two strands of No. 12 galvanized-iron wire. Better to attach it to pole as shown in Figure 36 before pole is set. Be sure the conductor is on the side where a line wire would not touch if it loosened from insulator. The upper end of the conductor should project about 4 inches above the top of the pole. Do not put lightning conductor on a pole in a low place where, if a line wire becomes loosened from an insulator, it may become grounded on the conductor.

The timber should be sound, entirely free from decay, carefully peeled, and thoroughly seasoned. In good seasoning weather open-piled stubs will usually season sufficiently in 90 to 120 days. Poles will take longer, or from 5 months to a year; Douglas fir, 5 to 8 months; lodge pole pine and western yellow pine, 5 to 7 months; western red cedar and western larch, 8 to 12 months.

**Preservative to be Used.**

A good grade of coal-tar creosote.

**Single-tank Method.**

With this method only one tank is used. (See figs. 37 and 38.) The creosote should be heated from 185° to 200° F. Add additional creosote to the tank to compensate for that absorbed by the wood. The material may be placed in the creosote after it is brought to the desired temperature, or at the ti. .e heating is begun. At the end of the heating period (from 3 to 7 hours), the fire is allowed to die down or is drawn. The timber is then allowed to remain in the cooling creosote from 3 to 14 hours, depending on the species to be treated. (See following table.) Care should be exercised that the creosote in the tank remains at about the same level, so that a penetration will always be secured for the required length. (Treatment should extend 1 foot above ground

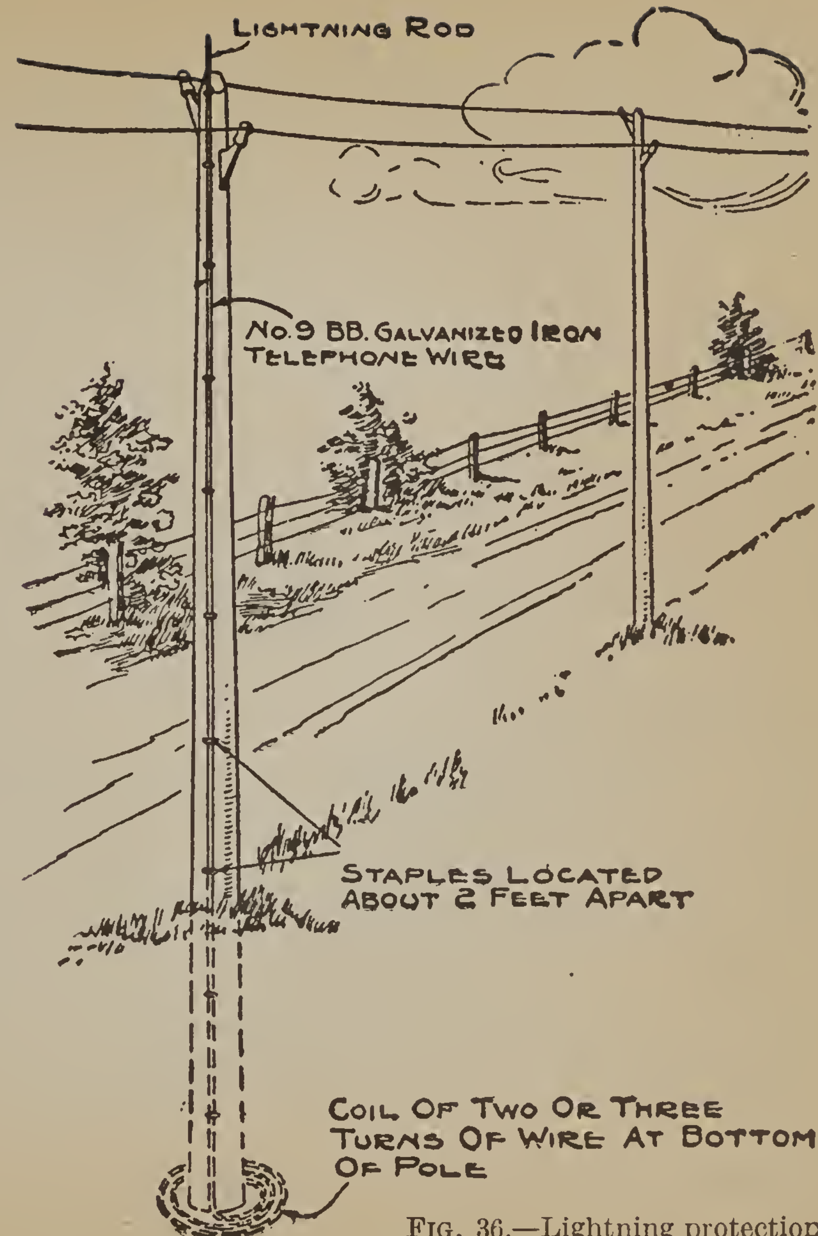



FIG. 36.—Lightning protection

line.) The stubs should then be removed from the tank to the draining trough, as shown in Figure 38. The surface creosote will drain off the stubs better if the oil in the cooling tank is slightly heated prior to the removal of the stubs.

The following table suggests the length of time the stubs should be left in the respective tanks:

*Time stubs in respective tanks*

| Species | Number of hours in hot creosote | Number of hours in cooling creosote |
|---|---|---|
| Lodge-pole pine (cut green and seasoned) | 7 | 14 |
| Lodge-pole pine (fire-killed) | 3 | 7 |
| Western yellow pine | 4 | 3 |
| Douglas fir | 7 | 14 |
| Western red cedar | 7 | 14 |
| Spruce | 10 | 20 |

**Double-Tank Method.**

In this method, two tanks are used, one for hot and one for the cold creosote. Heat creosote from 185° to 200° F. Place material in hot creosote, or in the preservative at the time the heating process is begun, leaving it there from three to seven hours. After material has been heated for the required length of time, quickly transfer it to the second tank containing oil at a temperature of about 100° F., or just warm enough to liquefy the oil thoroughly. Add oil as necessary to keep it of uniform depth.

**Results to be Secured by Both Single and Double Tank Methods.**

Penetration ranging from about ¾ to 1 inch for lodgepole pine and western yellow pine, and from ½ to ¾ inch for Douglas fir and cedar should give good results. The time necessary to secure any desired penetration will vary with the species, the moisture content of the material, and many other factors, and must be determined by actual tests in each case. And so at least one piece of timber each of the first six runs should be selected for tests.

The following table suggests the time the stubs should be left in the respective tanks:

*Time stubs in respective tanks*

| Species | Number of hours in hot tank | Number of hours in cold tank |
|---|---|---|
| Lodge-pole pine (cut green and seasoned) | 7 | 14 |
| Lodge-pole pine (fire-killed) | 3 | 7 |
| Western yellow pine | 4 | 3 |
| Douglas fir | 7 | 14 |
| Western red cedar | 7 | 14 |
| Spruce | 10 | 20 |

The best treatment is the one which gives the greatest penetration with the least absorption of oil. If the penetration of oil is not sufficient, either the hot or cold bath should be lengthened. If the penetration is satisfactory but too much oil is absorbed, the cold or cooling bath should be shortened. The schedules given should produce an absorption of from 4 to 8 pounds of oil per cubic foot of wood impregnated. In the experimental work, which has been conducted on lodgepole pine in district 1, with similar time schedules, the 6-inch by 25-foot poles and 7-inch by 8½-foot stubs absorbed about 1.5 gallons of oil for each stub. In using these figures in estimating the amount of oil required for a given job, allow from 10 to 20 per cent additional for evaporation during treatment.

To reduce volatilization of oil, the hot bath should be given at as low a temperature as possible, without impairing the treatment. In specifying 185° to 200° F. for the hot bath, it is assumed that the timber is thoroughly air-dry. If there is any question about the timber being seasoned sufficiently, temperatures of 200° to 205° F. should be used. The maximum temperature should not be allowed to go above 220°, as excessive heating is likely to check and weaken the timber, also unduly increase the loss of the oil through volatilization. There is also danger that the oil will boil over the sides of the tank and take fire when an open fire is used. The oil is not dangerously inflammable.

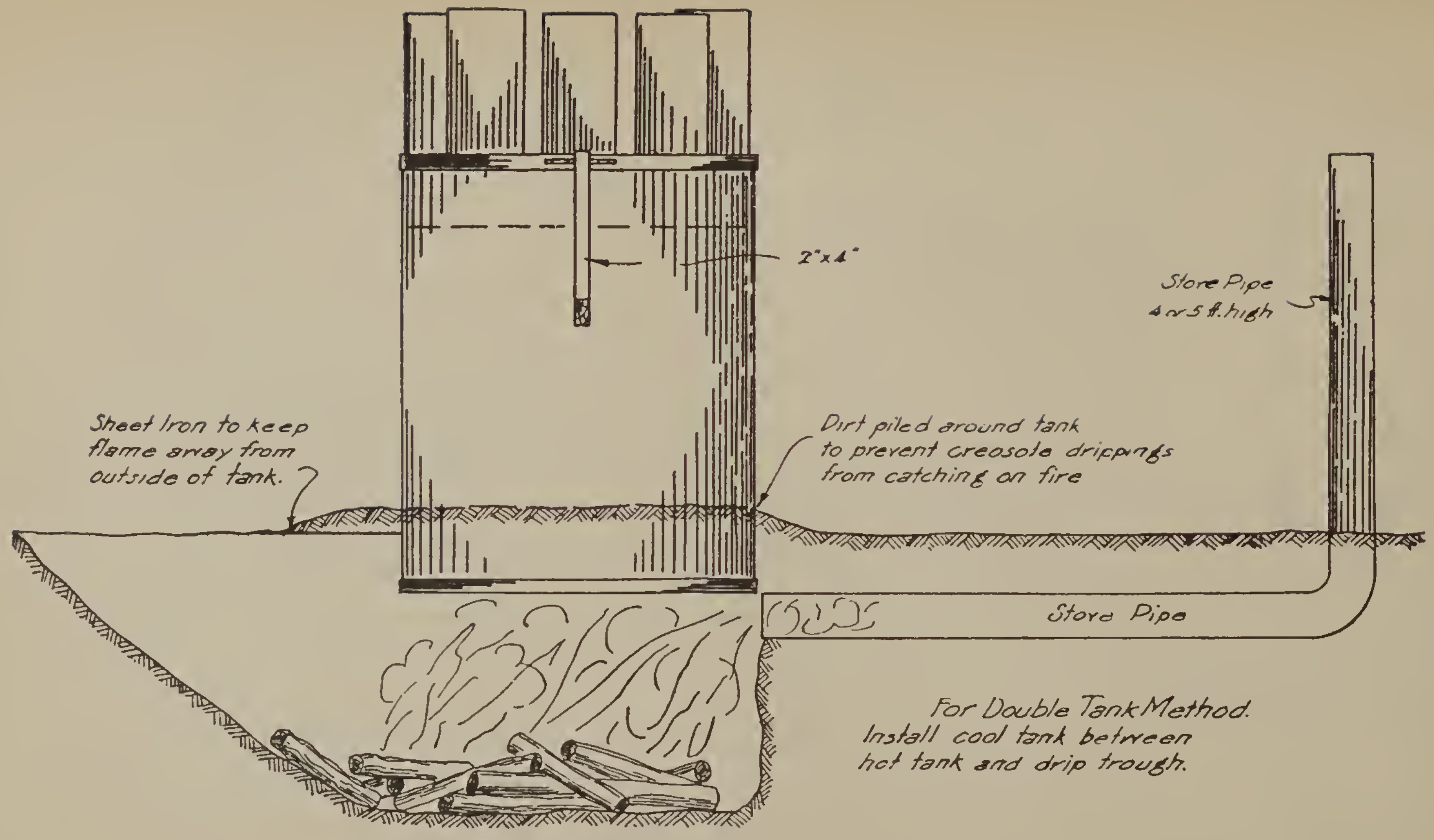



FIG. 37.—Creosote treatment of stubs, open-tank method

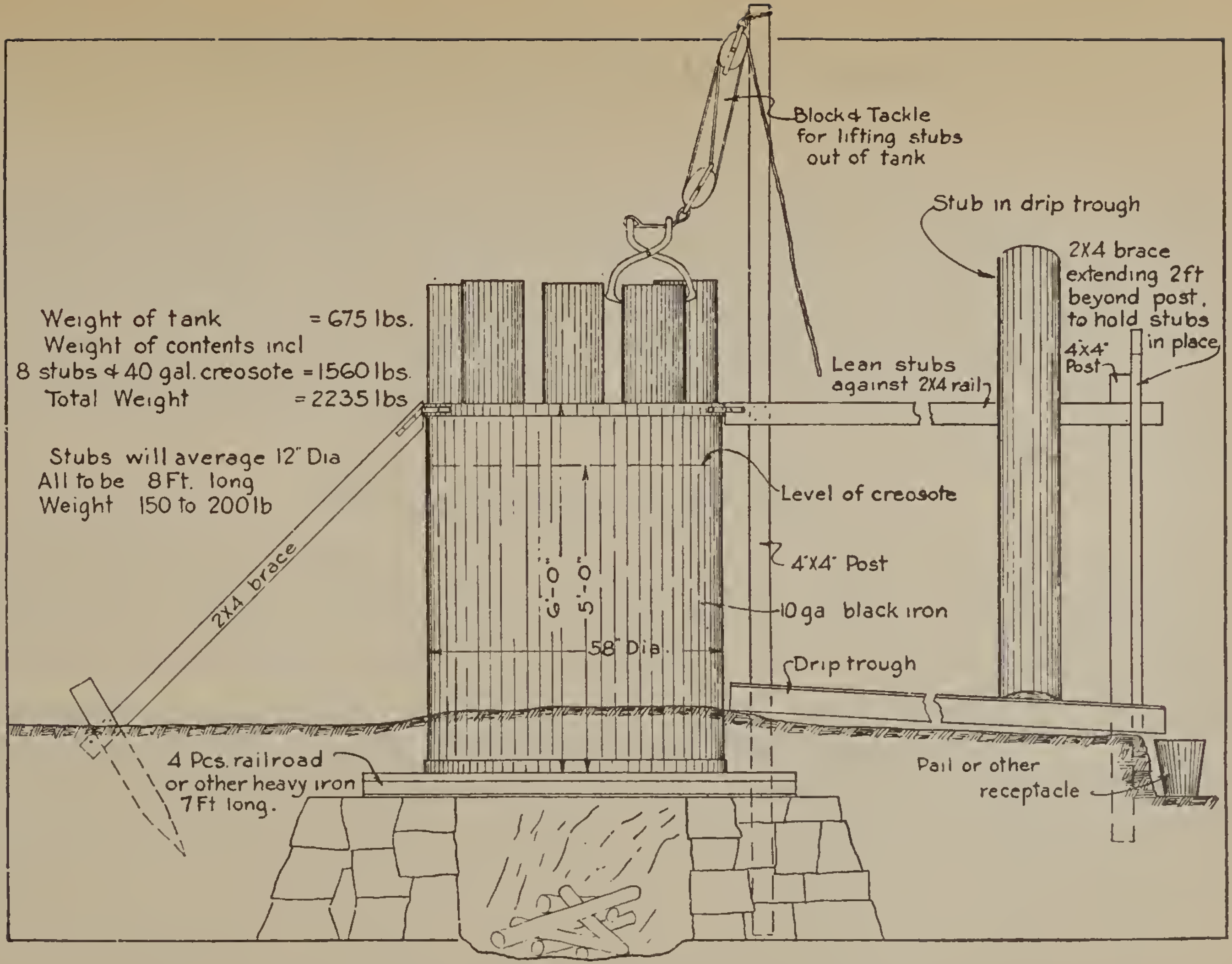



FIG. 38.—Creosote treatment of stubs, open-tank method

## RAILROAD CROSSING

A crossing of a railroad right of way shall be made as required by the railroad company, and also in compliance with the State laws. In any event there should be a minimum clearance of 30 feet above the rails. Ordinarily, it should cross at right angles and underground if possible. (See "Underground crossings," fig. 39.) If it is necessary to make an aerial (or overhead) crossing, it should be as specified in "Pole-line specifications."

In making an underground railroad crossing the line wire should be "dead-ended" to a tree or pole set on each side of the track, and properly guyed not less than 10 feet outside of railway signal wires or telegraph wires that run parallel to the track. The insulated wire should be carried down the pole and under the ground. (See fig. 39.) In no event should a pole be set closer than 25 feet to the center of the track. End poles to be either guyed or braced as shown in figures 30 and 32.

## ELECTRIC-POWER TRANSMISSION LINES

The crossing of high-voltage transmission circuits involves two difficulties: First, one of induction interference; and second, the physical job of safely crossing the right of way, both of which are technical problems that more often than not require advice from the district forester. So frequently is this the case that unless otherwise instructed by the district foresters, supervisors will ask for instructions before proceeding with the installation of power-transmission-line crossings.

The specifications for power-line crossings included in this section of the handbook appear for purposes of education and as a general guide to be followed on the job in conjunction with special instructions the district forester may work out in each particular case.

As a general policy the underground crossing of high-voltage lines is favored; however, in instances of a power line crossing a Forest Service telephone line, the Forest Service having the prior right of occupancy to the right of way can dictate methods, the expense of which the company should pay. Under these circumstances the so-called "short power-line span" crossing may be specified. The details of this form of crossing should be worked out by the power company subject to the district forester's approval. The minimum requirement should be that the crossing be at right angles and that the overhead span of the power line must be shorter than the

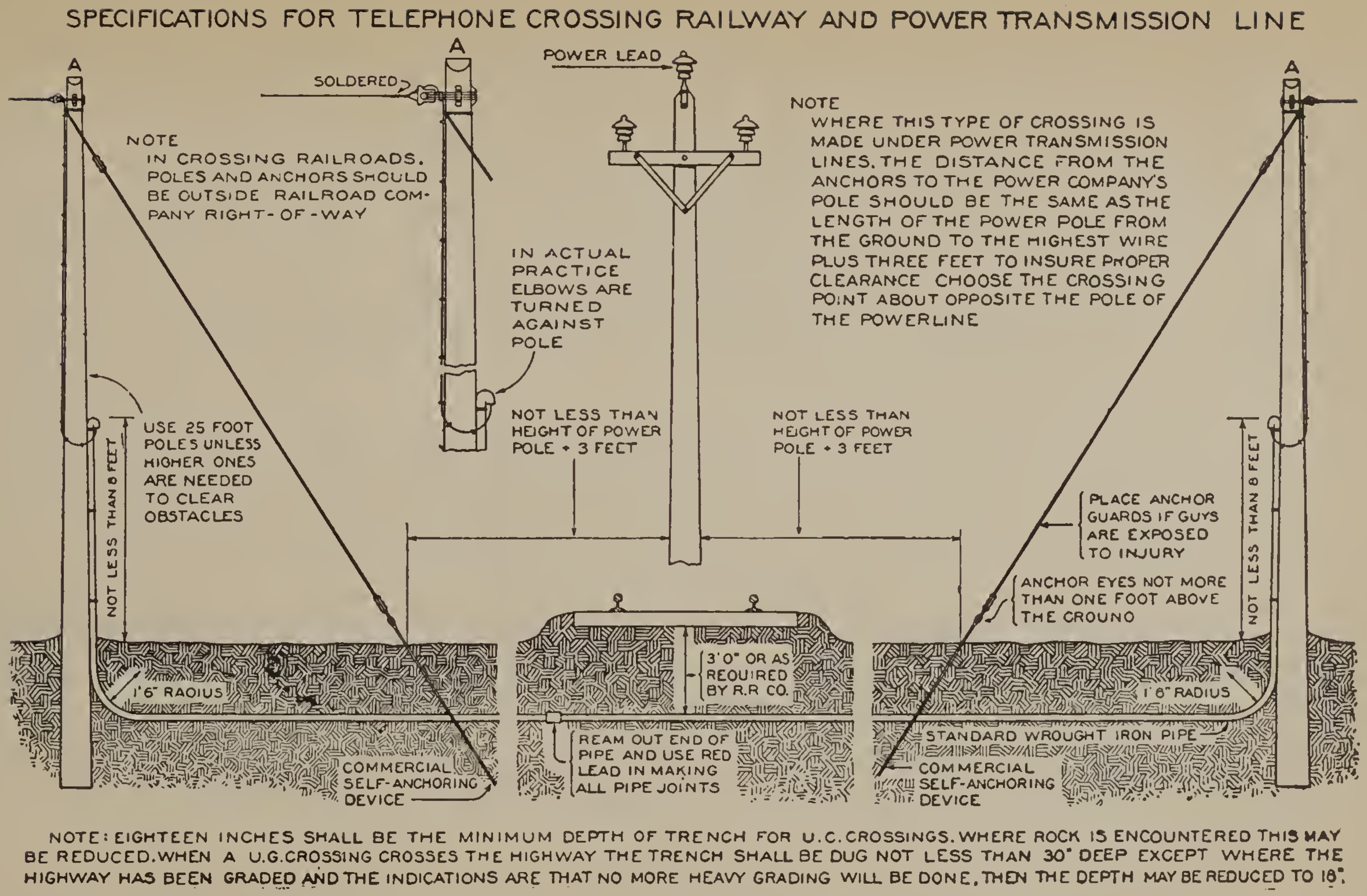



Fig. 39.—Underground railroad or electric power line crossing. If under power line, dead-end telephone line wire at least 50 feet from electric-power wire

vertical distance between the power line and the telephone line beneath. The latter requirement will make it impossible for a charged power line, if broken, to contact with the telephone circuit.

Telephone line wires should be dead-ended far enough away from power line to prevent a possible cross contact between power wire and telephone wire in the event of a break or a falling pole. Distance should be not less than 50 feet and poles should be at right angles to the power line.

The proper conduit to use for a single-wire, grounded line is the regular ¾ or ½ inch galvanized-iron conduit pipe. For the two wires of a metallic line use ¾-inch conduit. Both come in 10-foot lengths. If regular conduit pipe can not be obtained, use ordinary galvanized-iron pipe, but the burrs must be carefully reamed out of the ends before it is screwed together; otherwise the insulation on the wire may be ruined.

The conduit pipe should be buried or so located that it will not be subject to injury. All curves that can not be made by bending the pipe should be avoided.

In laying the conduit pass a piece of ordinary bare iron wire through the lengths of pipe as they are screwed together for use in pulling in the insulated wire after the pipe is bent and laid in place. Do not allow dirt or gravel to get into the pipe, as it may injure the insulation of the telephone wire. All pipe couplings should be water-tight, and as far as possible not made at a bend. If sharp curves are necessary, the wire should be drawn through each section separately and the conduit joined by a regular pipe union.

Lead-encased, single or duplex rubber-covered No. 14 copper wire is the most durable form of wire for use in underground crossings. Its use is favored. Second choice is No. 14 Brown & Sharpe gauge copper wire, with a triple-braid rubber-covered insulation. No connection should be made in wire that will come inside of a conduit. If the telephone line is metallic circuit and uncased wire is used, both wires should be twisted together or twisted-pair wire of the specifications may be used. If the wire is dusted with a little talcum tire powder, powdered soapstone, or ordinary flour, it will pull through the conduit more readily.

To keep water from getting into conduit pipe, a regular pipe cap should be slipped over the end of it after the insulated wire is drawn through. If a pipe cap can not be obtained, use an ordinary elbow, one-fourth inch larger in size than the conduit pipe.

## HIGHWAYS

Crossings over a highway if practicable should be at right angles, with a short crossing span. The wire shall be at least 20 feet above the road. In any event the requirements of the State law should be met. On

tree lines use two regular ties and insulators on the tree at each side of the road. On pole lines use two brackets on each pole at each side of the road.

### OTHER TELEPHONE LINES

Ordinarily, crossings with other lines should be aerial, with a short crossing span and a clearance of 3 or 4 feet between wires. Whether such crossings should be made with the telephone wire over or under the wires of the other lines will be determined by the danger of the other wires falling upon the telephone line, or by other local conditions.

### INTERFERENCES

Interference in the operation of a grounded-circuit telephone line may be caused by the proximity of—

(1) Another ground-circuit telephone line, or a metallic-circuit telephone line not properly transposed.

(2) An electric-power line.

(3) A telegraph line.

In order to overcome such interference, it is necessary to make the telephone line metallic as far as it parallels the other line. (Fig. 40.)

Static (or atmospheric) electricity may also cause a great deal of inconvenience in talking over grounded-circuit telephone lines. (See "Static interference.")

Two or more Forest Service grounded-circuit telephone lines may be on the same pole for 4 or 5 miles, provided the minimum distance between wires is about 2 feet. There will be little or no trouble caused by rings or howler signals, but there will be cross talk between the lines. The extent of this interference will be determined by the traffic (amount of talking) on the lines. If it can be avoided, a Forest Service grounded-circuit line should not be strung on the same poles with grounded-circuit lines owned by others.

It is not always possible to determine in advance the extent of the interference on a grounded-circuit telephone line caused by an electric-power line or a telegraph line, but probably it will be serious if either the power or the telegraph line is within 500 feet of the telephone line and extends parallel to it for more than 1,000 feet.

The static electricity that accumulates on a telephone line extending over places of high altitudes or through dry areas is very often the source of serious interference. This trouble may be partially overcome by connecting high-resistance drainage coils to the line, or through the use of a properly balanced by-pass and vacuum-tube amplifier at the telephone. Neither method should be attempted until definite instructions from the district

feroster are received. A special telephone (see "Special telephone") having a high-power transmitter has been used with considerable success for "outtalking" the static noise on a line.

### TRANSPOSITIONS

Transposition (see fig. 41) in a metallic line are changes in the relative positions of the two wires. Metallic lines should be transposed in order that the amount of interference from another line may be the same on each wire in the metallic line. This neutralizes the effect of the interference. Ordinarily three transpositions to the mile are sufficient when the metallic line parallels a grounded telephone line, a telegraph line, or an electric-power line. When paralleling another metallic telephone line, the transpositions in one line should offset the transpositions in the other line. A metallic telephone line which does not parallel another line for more than 3 or 4 miles, and is not within 200 feet of it, should have three transpositions per mile. These will be spaced so as to divide the line into an even number of equal lengths.

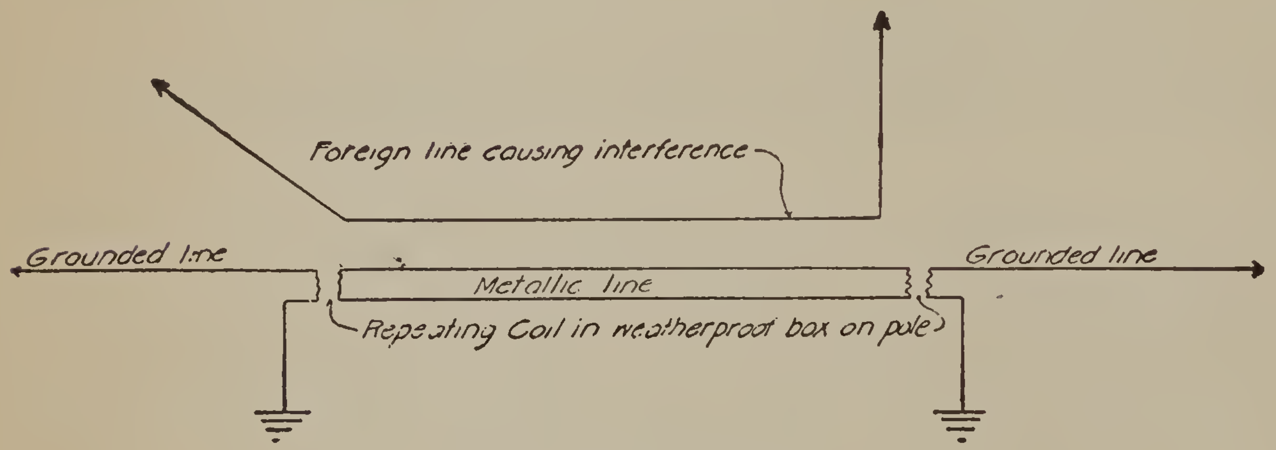


FIG. 40.—Line interference

The rotary form of transposition is probably the most satisfactory. This consists in carrying the left-hand wire over the other wire at each transposition.

Transposing the relative postitions of two grounded-circuit lines on the same pole does not reduce the cross talk between them.

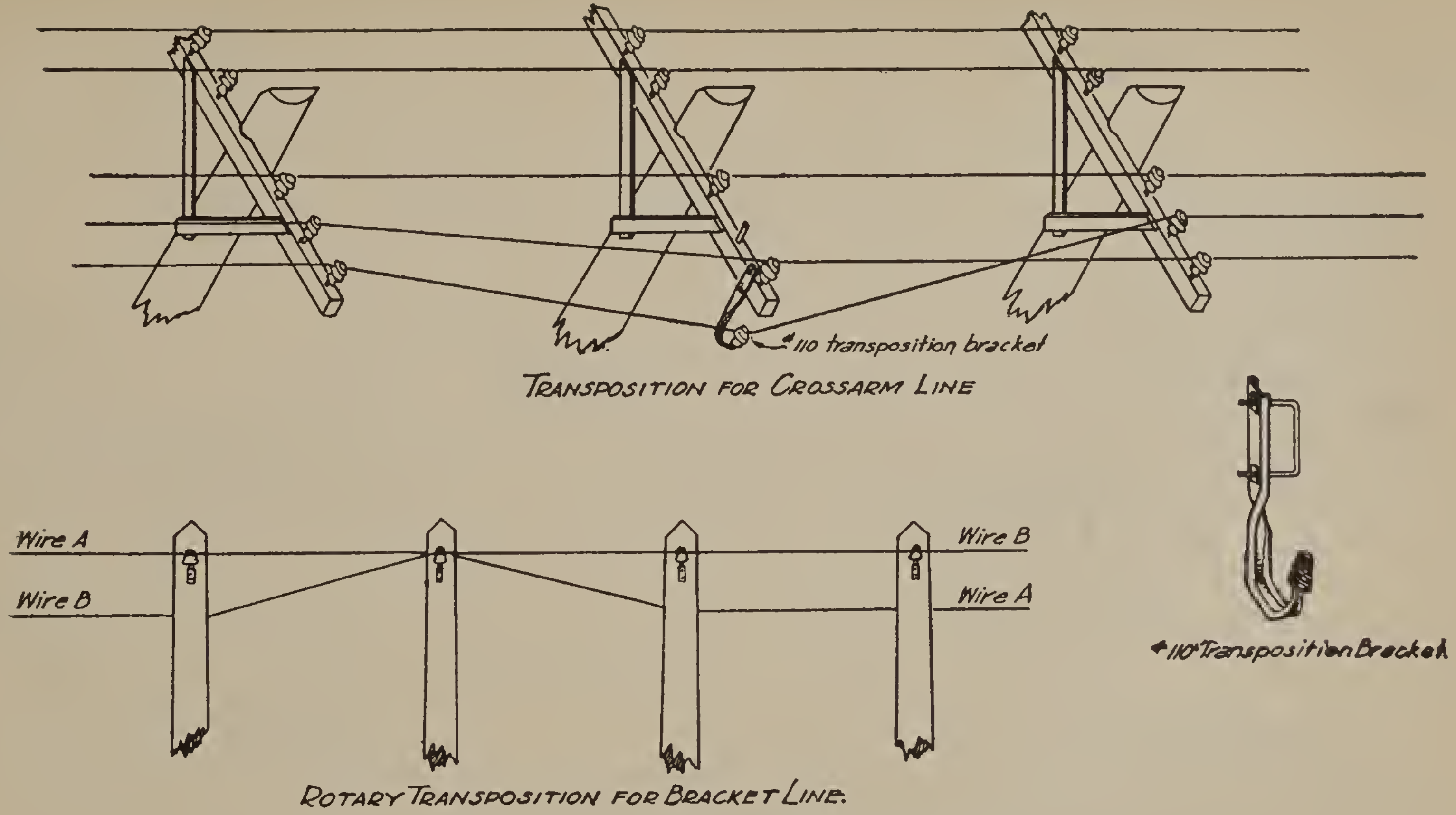
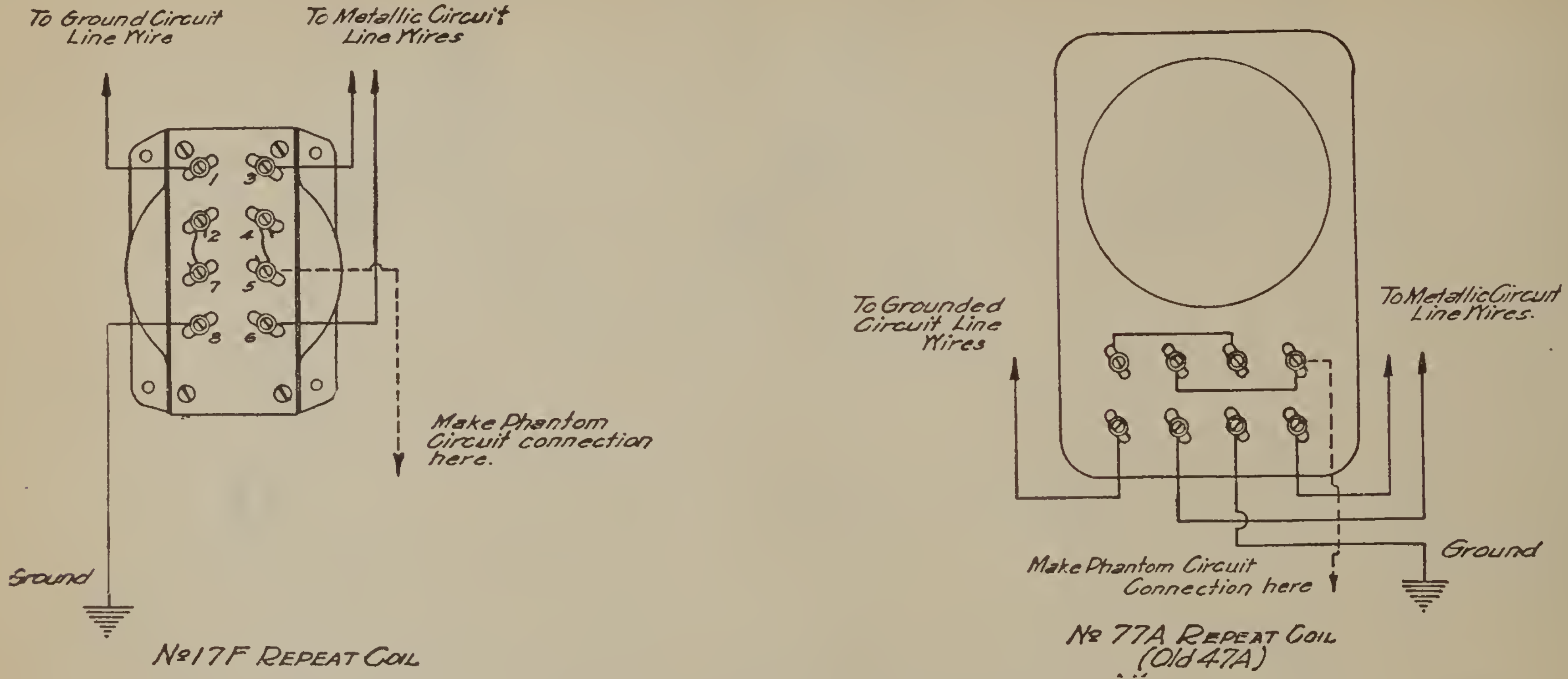



FIG. 41.—Pole-line construction transposition

A repeating coil connected as shown in Figures 42 and 43 should be used whenever it is desired to connect a metallic-circuit line and a grounded-circuit line together. In Figure 57 is shown a simple method of connecting




FIGS. 42 AND 43.—Methods of connecting repeating coils. For changing from grounded to metallic circuit or reverse

coil at a switchboard. On long, heavily loaded lines it may be advisable, on account of the added load of the repeat coil, to keep the coil off of the metallic-circuit line when it is not in use. This can easily be done by using a D. P. S. T. knife switch for making and breaking the connection.

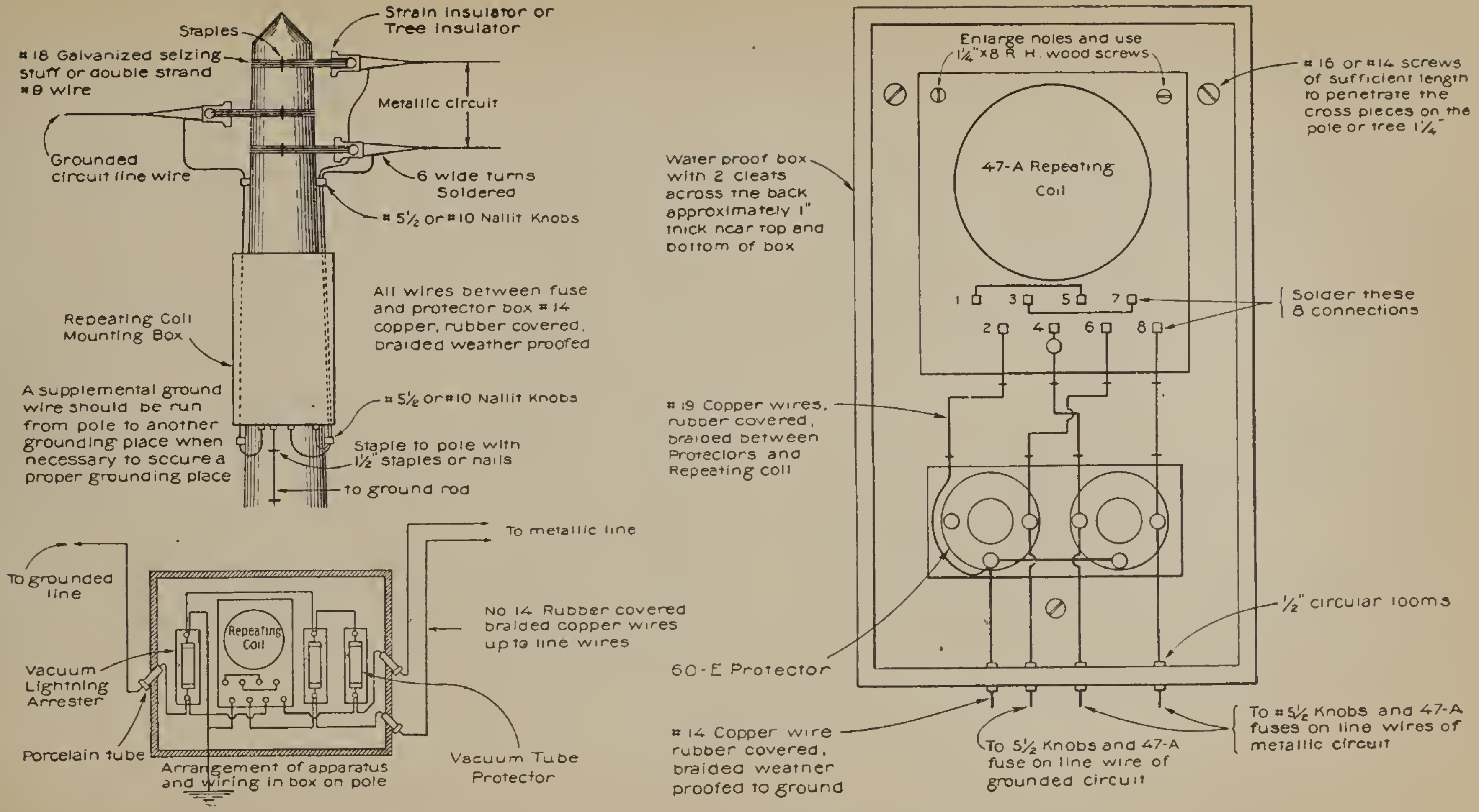



FIG. 44.—Out-of-door installation of repeating coil between metallic and grounded line

The equipment and material used and the character of the work done at all regular telephone installations will conform to the following specifications and general instructions:

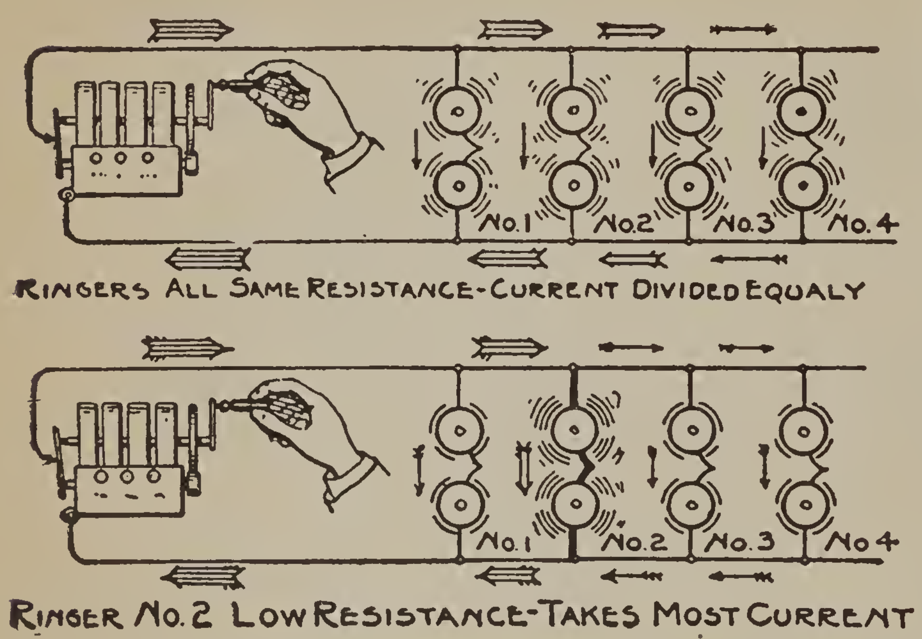



FIG. 45.—Illustrating necessity for all ringers to have same resistance

Each district shall standardize its type and make of telephone as far as practicable. Each telephone instrument shall be equipped with a generator having a ringing strength not less than that of a 5-bar magneto, a 2,500-ohm ringer (bell coils), and a condenser in the receiver circuit. (See "Condenser," p. 98.) While a 2,500-ohm ringer is the standard for all telephones and extension bells, there may be some instances where in the interest of better fire control it is good business to connect a Forest Service telephone line to one on which 1,600 ringers may be used. In this event it is necessary that all ring recoils connected to a line (or lines tied together) have the same resistance even if it will require the Forest Service to adopt the lower-resistance ringers on its connecting line. This is to be avoided if there is any other way out. One way might be to remove the bell coils in the 1,600-ringer telephones and substitute for them 2,500-ohm ringer coils. This would be a practical step only if the 1,600-ohm telephones were equipped with fire-bar generators.

### LOCATIONS OF EQUIPMENT IN A BUILDING

The telephone (and switching apparatus, if any) should be located where it will be the most accessible for use and as close as possible to the lead-in wires.

## DROP WIRE

Do not attach the line wire directly to the building. Use a pole or tree not over 125 feet away. Then run a drop wire of No. 9 or No. 12 iron wire to the building, attached as shown in Figure 46. If there is not liability of serious trouble from sleet or snow, the regular No. 17 copper-clad insulated drop wire may be used, or No. 14 R. C. S. B. copper wire may be used for a drop wire, provided it will not be over 50 or 60 feet long. Standard glass insulators and brackets may be used for dead-ending. The connection to the line wire should be soldered; but if this is not practicable, use a Fahnestock connector (fig. 47) or a test clamp. In no event should a copper wire be connected to an iron wire unless soldered or attached by means of a clip.

Make the drop wire reasonably slack to allow for possible pole or tree sway and to avoid humming. If there are two or more bare drop wires, space them far enough apart to prevent crosses. Do not make

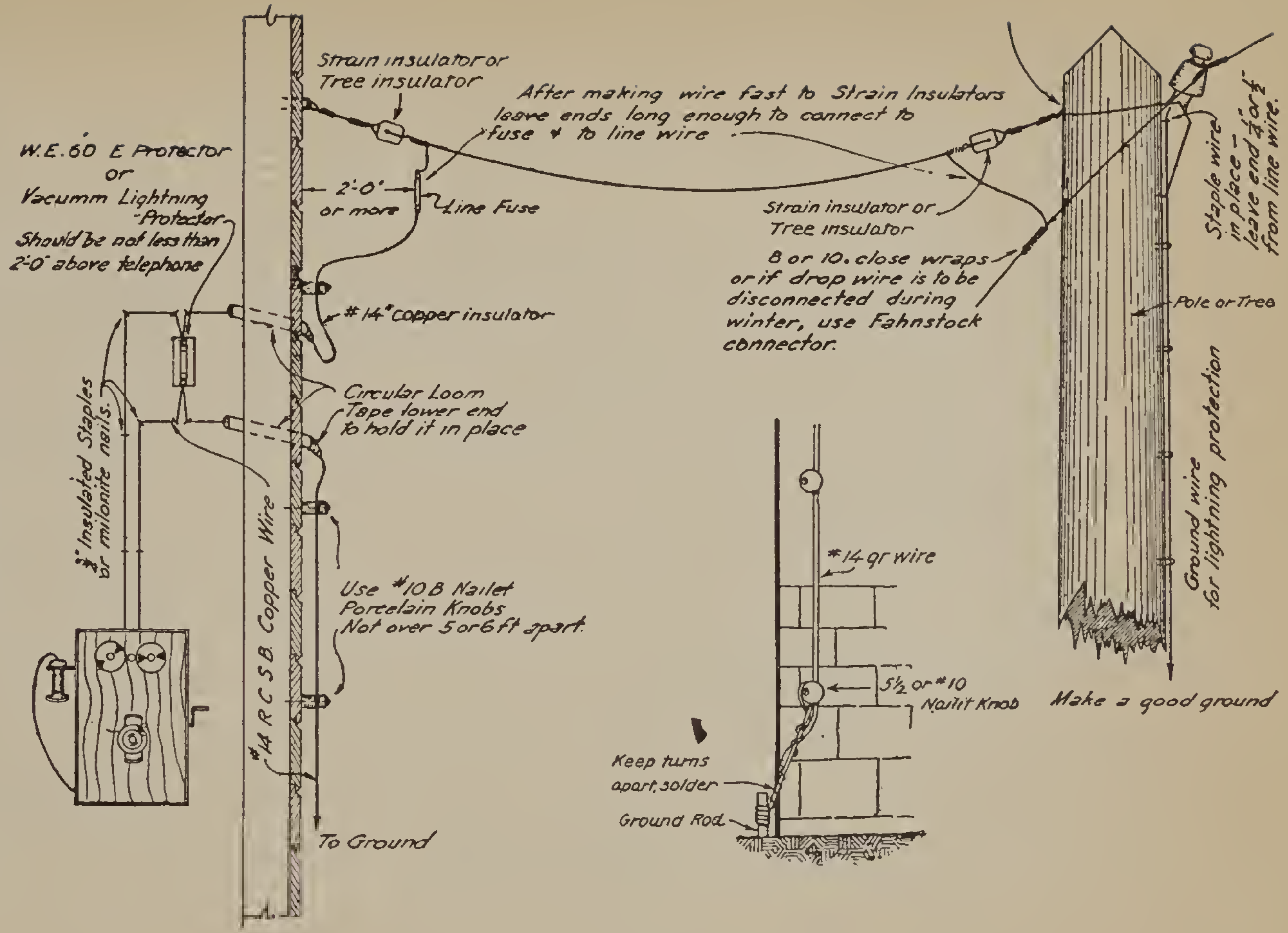



FIG. 46.—Telephone wiring and installation

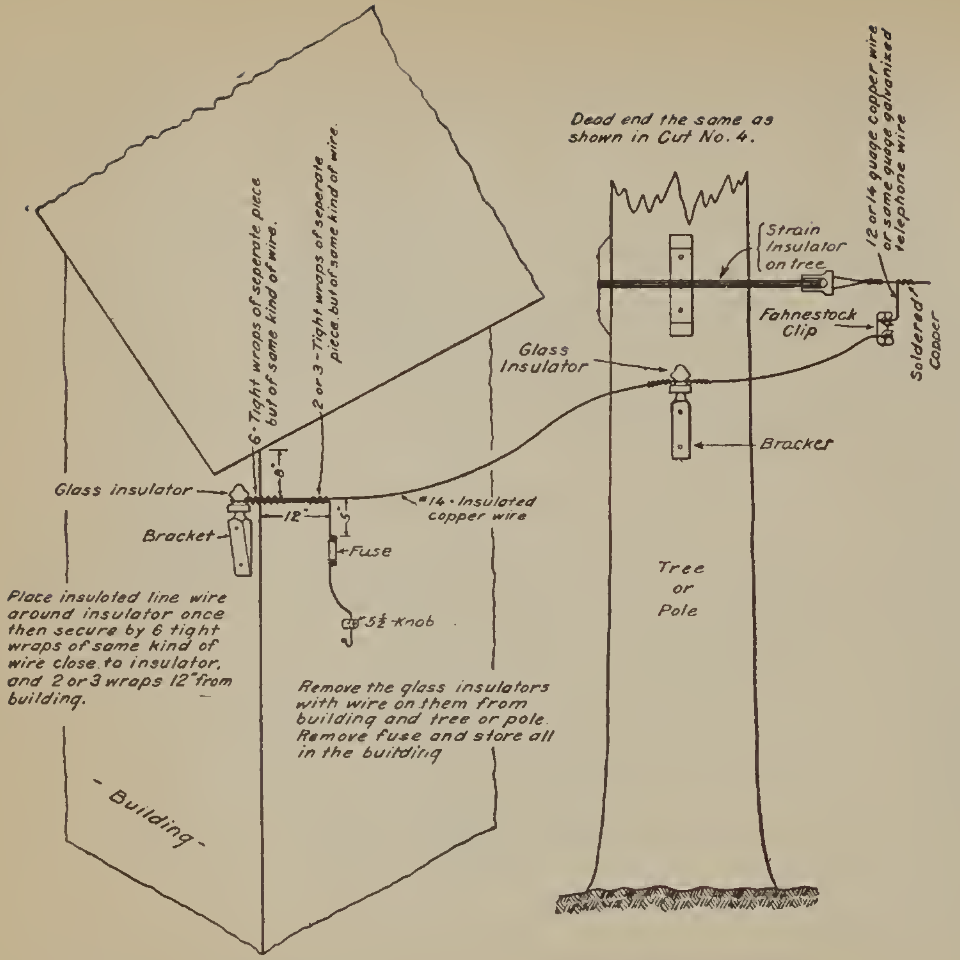



FIG. 47.—Method of installing drop wires at high elevations at uninhabited buildings during winter and where snow is heavy.

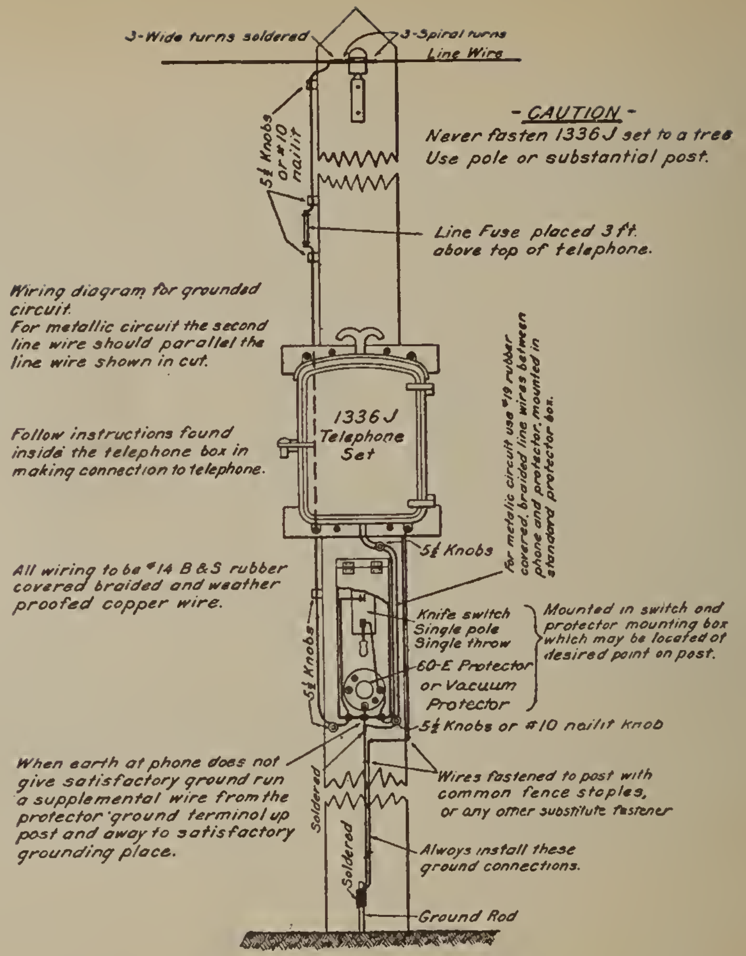



FIG. 48.—Wiring diagram for iron telephone installed outside.

attachment to the house under the eaves, where sliding snow from the roof may cause trouble. In some instances trouble will be saved by disconnecting one end of the drop wire at the end of the season and by rolling it up out of the way.

### LEAD-IN WIRES

Extend these from the lightning protector to the line fuse and to the ground connection. Use nothing but No. 14 rubber-covered single-braided (R. C. S. B.) copper wire.

### LIGHTNING PROTECTION FOR TELEPHONE INSTALLATIONS

A line fuse having a 5 or 7 ampere capacity (see "Line fuses") should also be installed on each line at each telephone installation; however, ordinarily line fuses will not be used at loop test stations. (See figs. 55 and 56.) As the line fuse requires from one-tenth to one-hundredth part of a second to "blow" and the initial lightning flash lasts only about one twenty-thousandth part of a second, the fuse is of value only to protect against possible "line surges" of electricity that may follow the initial discharge on a line. (See fig. 44.)

The principal function of the line fuse is to give protection against damage that may arise from the telephone wire contacting with high-voltage power circuit.

A lightning protector, either of the open-space (60–E) or vacuum type as outlined below, will be installed at all telephone stations (one connected to each line, if more than one). (See figs. 49, 51, and 58.)

In both the open-space (60–E) and vacuum type of arresters connections to the line and ground wire are brought close enough together for the lightning to jump the gap between them. In the open-space type (that has been commonly used by the Forest Service) the line and ground wires are connected to binding posts that are attached to two small metal blocks separated by a perforated strip of mica about one sixty-fourth inch thick.

A violent lightning discharge across this gap may fuse them together, which of course grounds the line. This is due to the presence of the oxygen in the air, which causes an electric arc. For this reason the open-space type of protector may not be best to use at stations not occupied continuously.

This protector is for mounting in a vertical position and must be placed as shown, with the tube end up. It is for indoor installation; when mounted outside it must be protected from the weather. The illustration shows method for connecting to a grounded line. To protect a metallic line, one protector should be connected to each wire.

45525°—25†——5

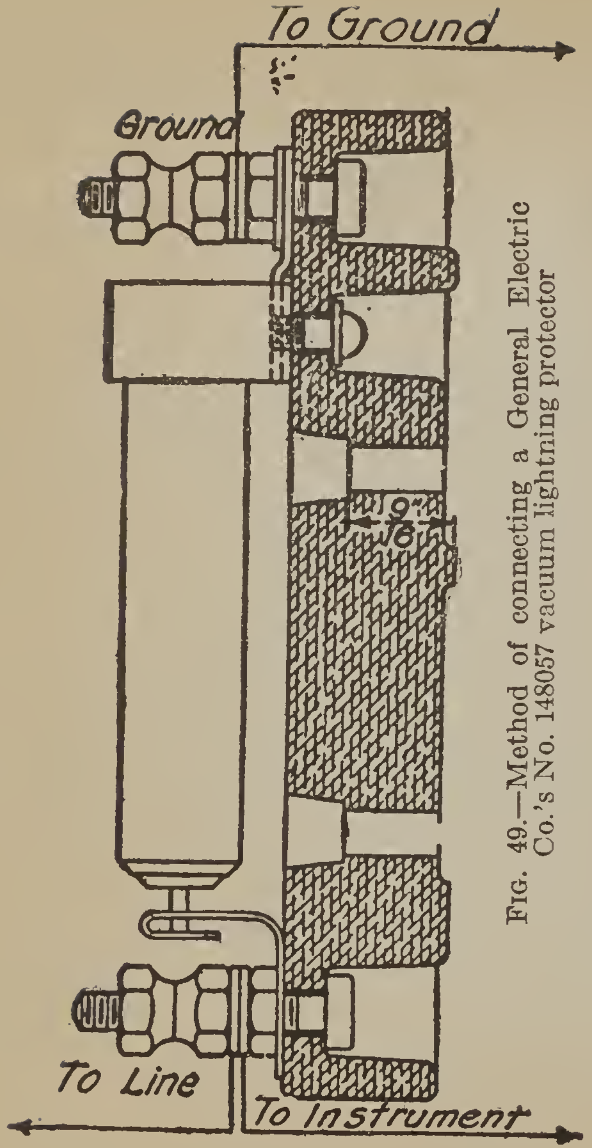



FIG. 49.—Method of connecting a General Electric Co.'s No. 148057 vacuum lightning protector

The principle of the vacuum protector is similar to the open-space type, the only difference being that the gap between the line and ground connections (which is about one-eighth of an inch) is inclosed in a tube exhausted to a high degree of vacuum, and there is no danger of them fusing together.

For this reason a vacuum lightning protector, although not made standard, is probably better and particularly at stations occupied only part of the time. Where lightning is usually severe, additional protection as outlined in Figure 50 is recommended.

## INSIDE WIRES

Extend these from the lightning protector to the telephone or other equipment. No. 14 R. C. S. B. copper wire is satisfactory for this purpose also and should be used as far as practicable. In no event should any wire smaller than No. 18 B. & S. gauge be used, and it must have a rubber insulation with a braided covering.

## WIRING

Attach wires to the outside of the building with porcelain knobs, either No. 5½ solid or No. 10 Nailit design, as shown in Figure 46. Use ¾-inch insulated staples inside. So far as possible make all runs either horizontally or vertically, with square turns, keeping the wire tight. Do not insert slack coils at any point. If there are two or more grounded circuits, keep the wires each 2 inches or more apart. However, if they run close together for any considerable distance there will be cross talk if they are only

2 inches apart. Avoid placing the wire in a damp place and do not use spirals or knots. If it is necessary to use old wire, cut out sections having defective insulation or old splices that have been badly twisted or kinked.

### SPLICING THE INSIDE WIRE

First cut the insulation loose from the wire with a sharp-edged knife, holding the blade almost parallel with the wire. Be sure to remove all of the insulation and to scrape the ends of the wires perfectly clean, but be careful not to make a nick in the wire, as this will cause it to break easily. Make a splice similar to the one described for the line wire. (Fig. 24.) The splice should then be soldered, using either resin-core solder or solder paste and solder, after which it should be covered with not less than two layers of ¾-inch friction tape. Acid-core solder may be used in connecting the No. 14 copper wire to galvanized-iron wire or iron pipe. However, acid-core solder must not be used for soldering any connections within instruments, or copper to copper.

### PERMANENT GROUNDS

Grounded lines must have a good electrical connection with the earth to overcome one of the greatest sources of trouble experienced with this type of line, which is the lack of proper "grounds." Faulty grounds are sometimes indicated by weak ringing, unsatisfactory speaking service, and "noisy lines."

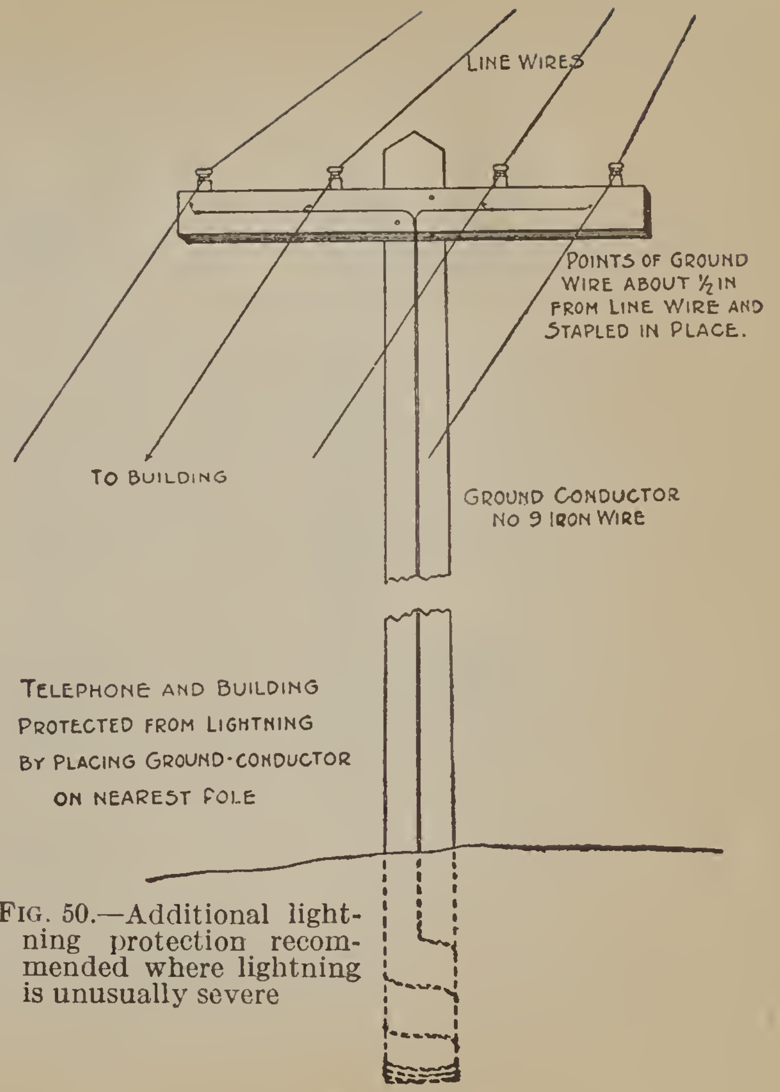



Fig. 50.—Additional lightning protection recommended where lightning is unusually severe

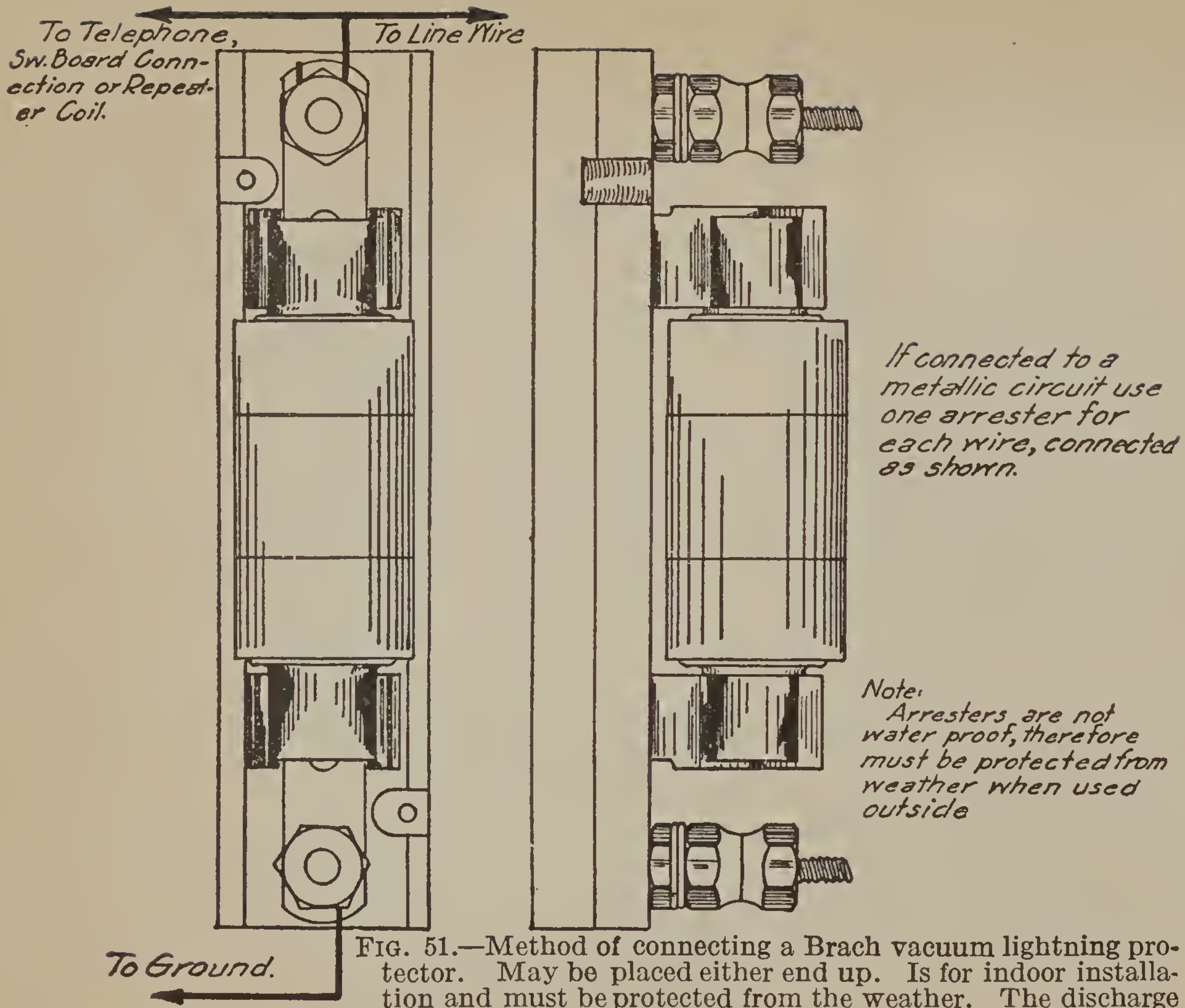



FIG. 51.—Method of connecting a Brach vacuum lightning protector. May be placed either end up. Is for indoor installation and must be protected from the weather. The discharge gap is about ¼ inch. Discharge starts at 200 volts. Capacity of arrester is 20 amperes

The earth is a freaky conductor. The various geological formations do not possess the same degree of conductivity. Therefore earth permanently damp does not in every case give a satisfactory ground. It is often necessary at the expense of much time and labor to test several places before a good ground can be found. The test connection can very conveniently be made by using the standard emergency wire.

Dry earth and rocks are nonconductors and should always be avoided.

Never attach ground wires to—

(1) Water pipes of a town water supply if other lines are grounded to them. (This tends to make ground noisy.)

(2) Pipe lines not carrying water.

(3) A coil of iron wire of any kind, or scraps of iron thrown into a stream, lake, or pond having a rocky bottom.

(4) Iron wire of any kind, except as a temporary expediency, as a substitute for standard copper-clad ground rods.

(5) Black-iron plates, horseshoes, gun barrels, ungalvanized bars of iron, or other similar articles. Ungalvanized iron placed in contact with the earth and black iron rust quickly. Rust is a nonconductor and acts as an insulator. Ground trouble is certain to follow if the above articles are used.

### MATERIALS SATISFACTORY FOR GROUND CONNECTION

(1) Use standard, copper-clad, iron or steel, ground rods wherever possible. The rod should be driven to within 8 inches of the top end into permanently damp earth. It should be placed as near the instrument as practicable to find satisfactory ground. If it is not possible to drive the rod its full length vertically, it should be driven on a slant.

(2) Wherever standard, copper-clad, iron or steel, ground rods should be used, but are not available, a Paragon ground cone, a copper sheet (24-gage) 2 feet square, or a coil of copper wire, as indicated elsewhere, may be substituted. The coil should always be deeply buried, with an end extending above the surface of the ground or water in order to provide for a connection with the wire leading from the instrument.

(3) Whenever a well is used for a grounding place, a coil of No. 10 bare copper wire about 12 inches in diameter containing 8 turns should be placed flat upon the bottom of the well. Sufficient length of the copper wire to extend fully 3 feet above the high-water level to provide for a connection to the wire leading from the instrument should be allowed.

(4) When it is impracticable to find permanently moist earth, a good ground may be obtained by placing a similar coil of copper wire, or a sheet of 24-gage copper, 2 feet square, with a No. 10 copper lead-off wire soldered to it, at the bottom of a hole 6 to 10 feet deep. A projection of the copper wire should be extended to the surface of the ground to provide for connection to the wire leading to the instrument. The coil should be covered with about 1 foot of pulverized charcoal, mixed with salt, over which the dirt should be placed to a depth of about 3 feet. Great care should be taken to see that the earth and charcoal are thoroughly drenched with water, and that the hole is refilled with dirt and securely tamped.

The charcoal will retain moisture. Water should be applied to the earth over the coil at frequent intervals during the dry period.

Mixing earth with salt and packing it around a sheet of copper or the coil of copper wire is a good way to improve natural grounding conditions. The packed earth and salt should be moistened before covering. Salt is hygroscopic and keeps the earth with which it contacts permanently moist.

## TESTING FOR GROUNDS, METHOD OF

A test for a ground for one instrument or bell may be conveniently made by the use of the emergency wire extended from the instrument to selected grounding places.

Where more than one line enters a station to telephones, extension bells, or a switchboard, all the instruments having the same ringer resistance may sometimes be grounded on the same ground rod or coil, provided the electrical contact to the earth is satisfactory.

The efficiency of a common ground should first be tested before making permanent connections to it. Where the rod or coil is immediately adjacent to the instruments, simply connect it to the instrument by a temporary wire. All points of connection should be clean and tight. Common ground-wire cross talk in some cases is largely due to having too small a ground wire. Extra large or multiple wire will often reduce it to the minimum.

If a satisfactory ground can not be found near by, the test may be made by stringing emergency wire to different satisfactory-appearing places until good grounds are found. (Test by attaching one instrument to the wire leading to the experimental grounding place, and if satisfactory results are obtained connect in turn lead wires from each additional instrument.) Cross talk between the lines may be heard even if the ground is good, but it should not be pronounced. When a signal is rung over one of the lines the bells should not cross ring; that is, two bells or more ring with the switches open between the respective lines. If the cross talk is loud and the bells cross ring, or if the cross talk is loud in the absence of cross ringing, inadequate ground to carry the full number of instruments attached is indicated.

Further experiments should be made by disconnecting one instrument at a time from the lead wire, followed by a test until the cross ringing is eliminated and the cross talk either eliminated or much weakened. Only in exceptional cases, if ever, can cross talk be entirely eliminated where several grounded lines enter the same station. Seek additional ground or grounds for lines that were disconnected.

It may be necessary in some cases, in order to get satisfactory service, that grounds be separated as much as half a mile. The expense, however, of locating efficient ground and of installing connecting facilities is justified, because communication over a telephone line is largely a failure unless grounds are good.

## SOLDERING GROUND CONNECTIONS

Invariably solder all connections between the protector and the object used as a ground.

| | |
|---|---|
| Equipment | Soldering irons (½ and 1½ pounds).<br>Solder, resin core for light and medium heavy work.<br>45–55 solid wire solder.<br>Western Electric or Allen's soldering stick (soldering flux). |

Joints, splices, and other direct contacts in installation work should be soldered, except standard line-wire splices.

All parts to be soldered must first be thoroughly cleaned, by scraping or filing or otherwise, before spliced and flux and solder is applied. Care should be taken not to entirely remove the galvanizing in cleaning galvanized-iron wire. Confine the cleaning process to the section to be soldered only. Before resoldering terminals all traces of old solder should be removed by scraping it off with a well-heated soldering iron.

**Use of Resin-Core Solder.**

Resin-core solder should be used for light work and medium-heavy work, such as soldering copper joints, copper to brass, copper to iron, and connections inside of telephone instruments, etc. In emergency cases it can be used for heavy work.

To apply: Heat the joint with the soldering iron (do not attempt to apply the solder with the iron), just enough to melt the resin forming the core of the solder when it is rubbed on the hot surface. Since copper wire oxidizes (turns dark red) when heat is applied, care should be taken to have the melted resin well distributed over the joint before the change of color takes place. Solder will not adhere to oxidized copper. A low degree of heat will melt the resin core of the solder before the oxidizing occurs and the solder begins to melt. As the resin is distributed the increased heat of the joint will cause the solder to flow. The successful use of resin-core solder depends largely upon attention given to the work and the skill used in heating the joint. *Remember that resin-core solder can not be applied with a hot soldering iron and its own flux to a cold surface. Neither will it adhere to an oxidized joint.*

**45-55 Solid Solder.**

First heat the joint sufficiently with the soldering iron to cause the bared end of the flux stick to melt. Secondly rub the stick along the entire length of the joint until a coat of the flux is well distributed. Then with

a hot soldering iron placed on the joint melt and apply the 45–55 solder. As the solder melts it will flow readily into place if the wire has been heated to the proper temperature.

**To Solder to Black-Iron Pipe.**

(1) First thoroughly clean a strip on the pipe about ½ inch wide and 2½ inches long.

(2) Heat the cleaned place, either with the flame of a gasoline torch or a heated iron, until it is hot enough to melt the soldering flux.

(3) Distribute a coat of flux over this point by rubbing stick over it.

(4) With a well-heated soldering iron distribute 45–55 solid solder over the cleaned space, which should be about as hot as the soldering tool.

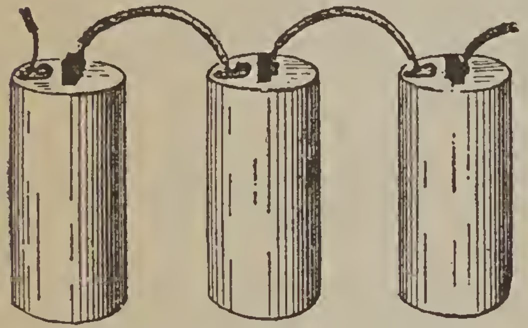


FIG. 52.—Method for connecting dry batteries

(5) Then tightly wrap the wire, well cleaned, around the pipe, leaving at least ⅜ inch between each turn.

(6) Fasten the end of the wire at the end of the coil by twisting it around the wire leading from the pipe.

(7) Apply an additional coat of flux.

(8) Then apply the 45–55 solid wire solder in the regular manner.

## BATTERIES

Use at least three regular telephone dry batteries for each standard telephone. On long lines the instrument farthest away might give better service if four batteries are used. These should be fresh and the installation date marked on the cardboard cover. Connect them, carbon to zinc, as shown in Figure 52. For ordinary use a set of batteries will last for one season, but in any event new batteries will be placed in all telephones before the opening of each fire season.

If avoidable, at unoccupied stations, batteries should not be left in telephones during the winter months. This is particularly important in the case of iron-box telephones.

## DISCONNECT SWITCHES

(See figs. 53 and 54.) These switches will be installed at all stations not continuously occupied. This permits disconnecting the telephone and reduces the load on the line where there is no one at the station.

## LOOP TEST SWITCHES

(See Figs. 55 and 56.) These should be installed only at points where it may be desirable to cut the line in two for testing either end. Care should be taken not to locate them where there will be danger of one being accidentally opened. If there is any doubt, put them in a box with Forest Service lock.

## TESTING

After the job is completed, go over screw connections to see that all are tight. If an old style 60–A lightning protector has been used, see that the contact blocks in them are clean, and also that there is a strip of mica between them. If carbon blocks are found, replace them with alloy blocks. Be sure that the ringer is properly adjusted. (See "Ringer adjustment.")

Make final test by calling up another station some distance away and have them give you a ring. If a howler has been installed, have some station equipped with an Adams portable, or a howler coil (see fig. 71), give you a "howl." Then make needed adjustment as described under "Howler adjustment."

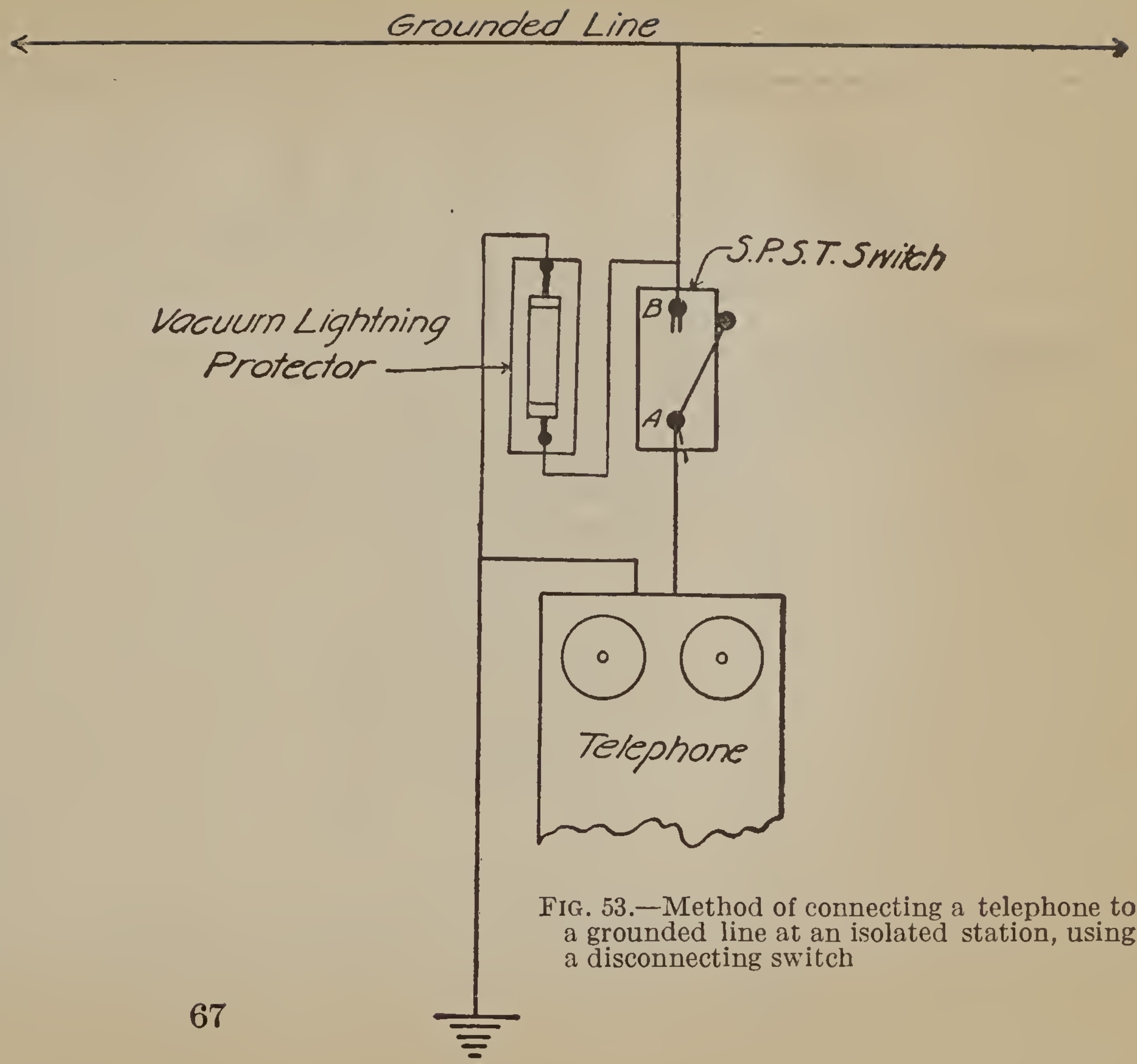



FIG. 53.—Method of connecting a telephone to a grounded line at an isolated station, using a disconnecting switch

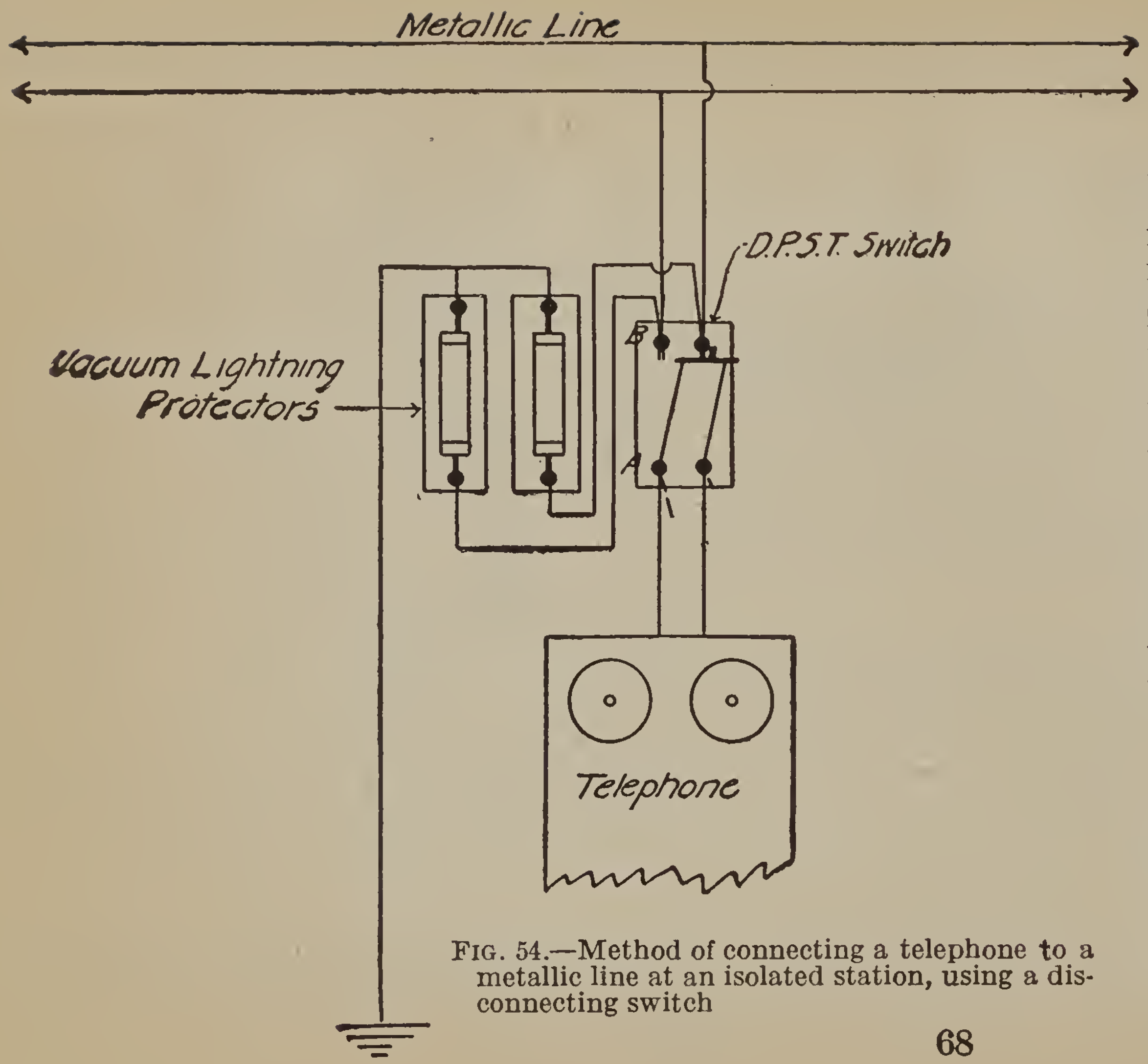



FIG. 54.—Method of connecting a telephone to a metallic line at an isolated station, using a disconnecting switch



# SWITCHBOARDS

## KNIFE SWITCHES

These will be satisfactory for use in making switching connections between two or more lines at stations where the switching is not heavy. (The contacts wear out if used frequently.) Convenient arrangements of the switches and other equipment for two to four lines are shown in Figures 57, 58, 59, and 60. Figure 58 is the same as Figure 57, except that the 60–E protectors are used. These are not standard methods. They are included in this manual as general guides.

Plan as shown in Figure 60 requires only one extension bell and is for a station having lines that normally are left connected together and to the telephone all of the time, but where occasionally it is desired to cut one line off.

## PLUG AND JACK SWITCHBOARD

Following are circuit diagrams and instructions for the construction of a switchboard suitable for use at important line centers, where the switching is too heavy for the knife-switch type of board. The complete board, including both plug and

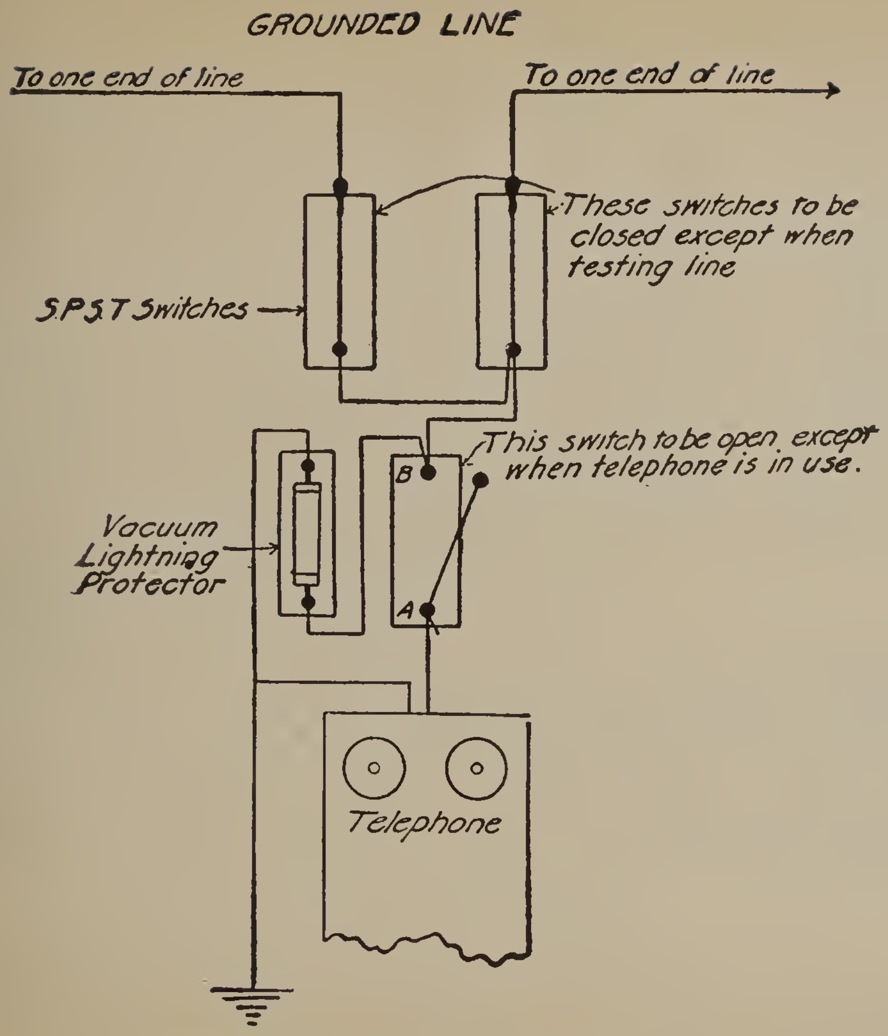



FIG. 55.—Method of installing a test station on a grounded line

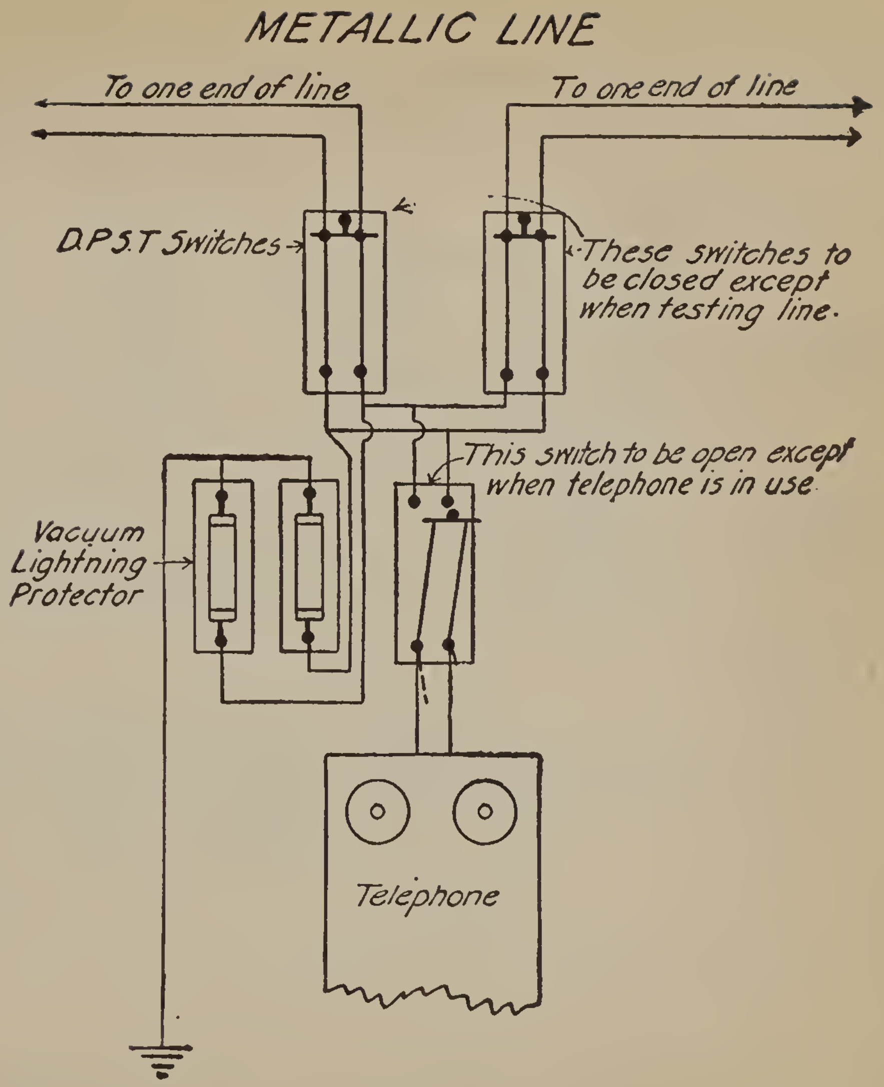



FIG. 56.—Method of installing a test station on a metallic line

jack, bell and howler sections, may be built, using an ordinary flat-top table (similar to a regular office table), or the plug and jack section may be built separately to attach to a wall.

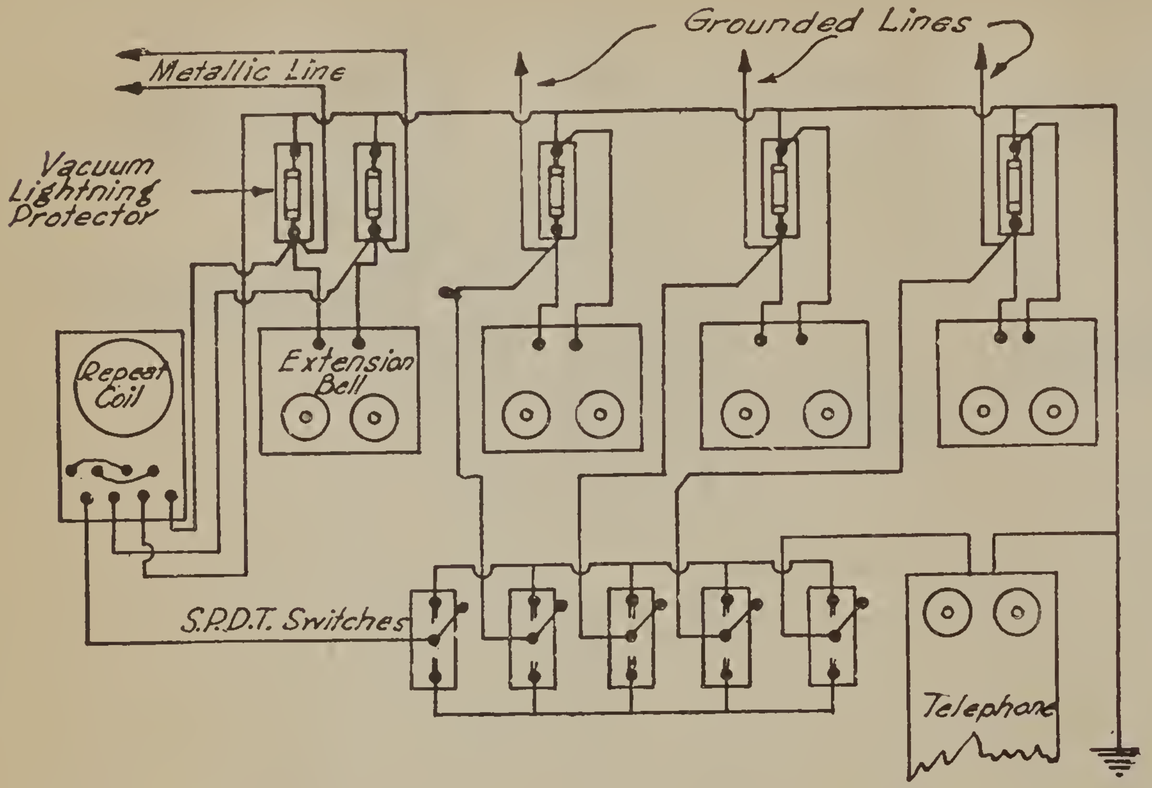



FIG. 57.—Switching station for one metallic and three grounded lines, showing connections for vacuum protectors

The front view of the plug and jack section of a five-line switchboard is shown in Figure 61, and a cross-section detail is shown in Figure 62. The circuit diagram for each line is shown in Figure 64, and in Figure 65 for a metallic-circuit board. There is a duplicate of this circuit for each line connected to the board. For instance, for a 5-line board there will be required 6 plugs, 6 cords, 6 cord weights, 5 jacks, and 10 binding posts (15 for a metallic-circuit board) to provide for the lines; one extra plug, cord, and cord weight required for operator's telephone. (Fig. 63.)

The circuit for the operator's telephone and howler set is shown in Figure 63. Omit the howler-coil wiring if it is not desired to use this method of signaling. (See "Howler method of signaling," p. 78.) In this event the operator's cord and plug are connected directly to the wire from the operator's telephone and only one binding post is needed (two if board is metallic).

When it is not desired to have the bells (and howlers) attached directly to the plug and jack section of the board, mount them on a board as shown in Figure 66. This may be located in any convenient place and the line wires extended from the proper binding posts on the terminal strip in the plug and jack section. (See fig. 64.)

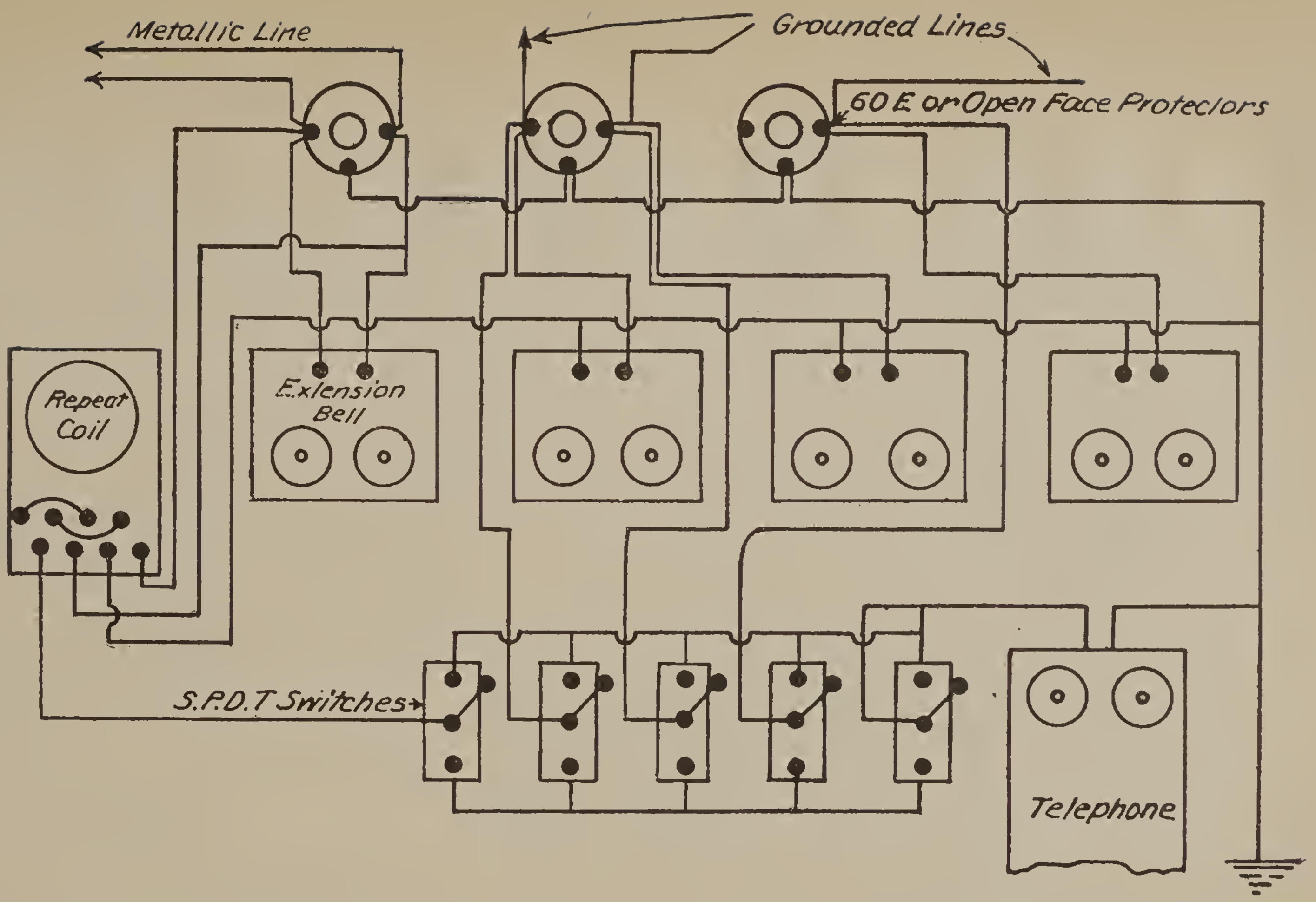



FIG. 58.—Switching station for one metallic and three grounded lines, showing connections for 60-E protectors

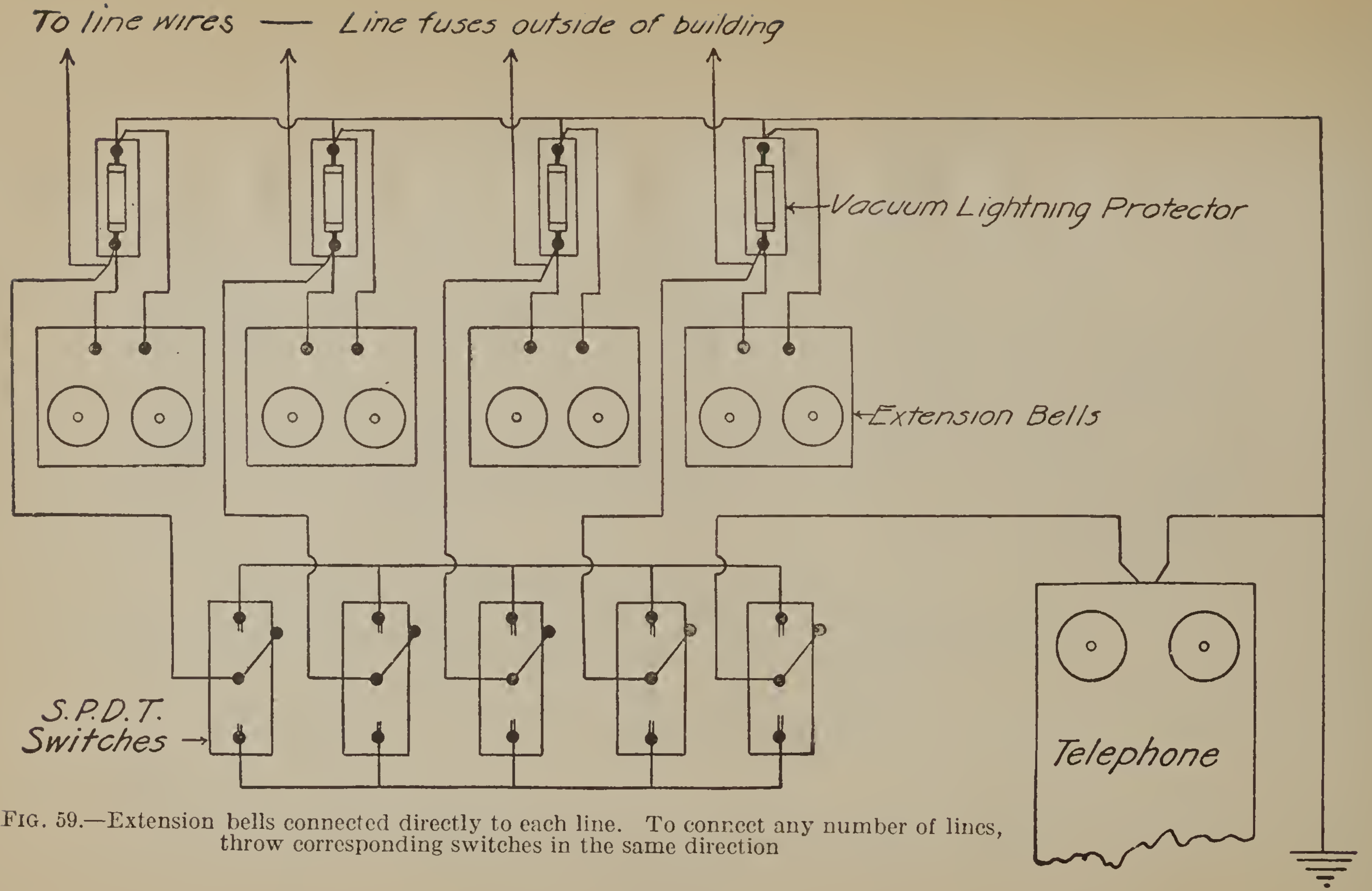



FIG. 59.—Extension bells connected directly to each line. To connect any number of lines, throw corresponding switches in the same direction

The schematic wiring diagram of a complete five-line grounded-circuit switchboard is shown in Figure 67. If the howler coil is not desired, leave off the first seven binding posts from the left and the fifth one from the right and connect the operator's plug and cord to next binding post left (sixth from the right-hand end). If the dispatcher's set (Wonderphone) (see "Dispatcher's set" under "Special equipment") is not installed, leave off binding posts Nos. 1 to 4, inclusive, from the right.

### "TUNING" EXTENSION BELLS

At stations having several extension bells different toned gongs should be purchased or the regular gongs should be "tuned" by sawing a slot from the outer edge of the gong toward the center, varying the length of the cut to change the tone. This is very easily done with an ordinary hacksaw.

## SPECIAL EQUIPMENT AND METHODS

### HOWLERS

A howler is merely a high-resistance receiver with a special diaphragm having a horn attached. It is necessary to have

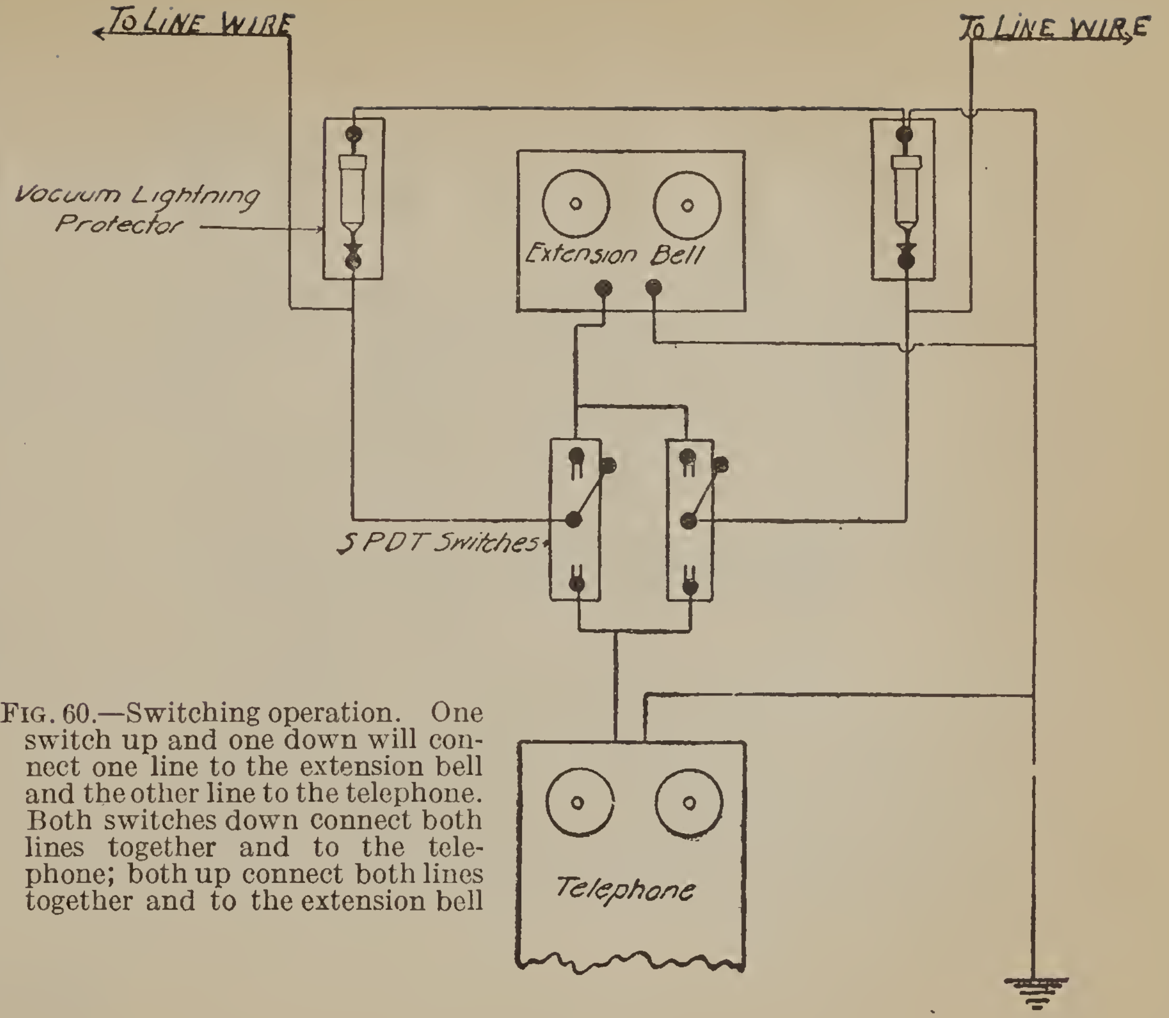



FIG. 60.—Switching operation. One switch up and one down will connect one line to the extension bell and the other line to the telephone. Both switches down connect both lines together and to the telephone; both up connect both lines together and to the extension bell

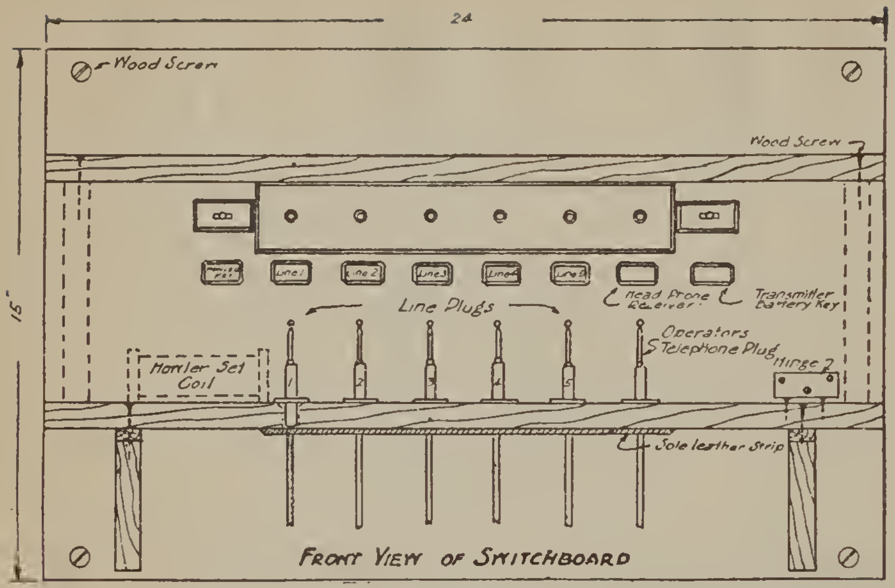



FIG. 61.—Location of plugs and jacks in a 5-line switchboard. Space the jacks about 2 inches apart, and corresponding plug directly in line. If howler coil is used (see fig. 46), locate as shown in dotted line with key for operating it to left of jack, mounting strip as shown. Locate key for transmitter batteries (see fig. 54), "special equipment," right of mounting strip, as shown

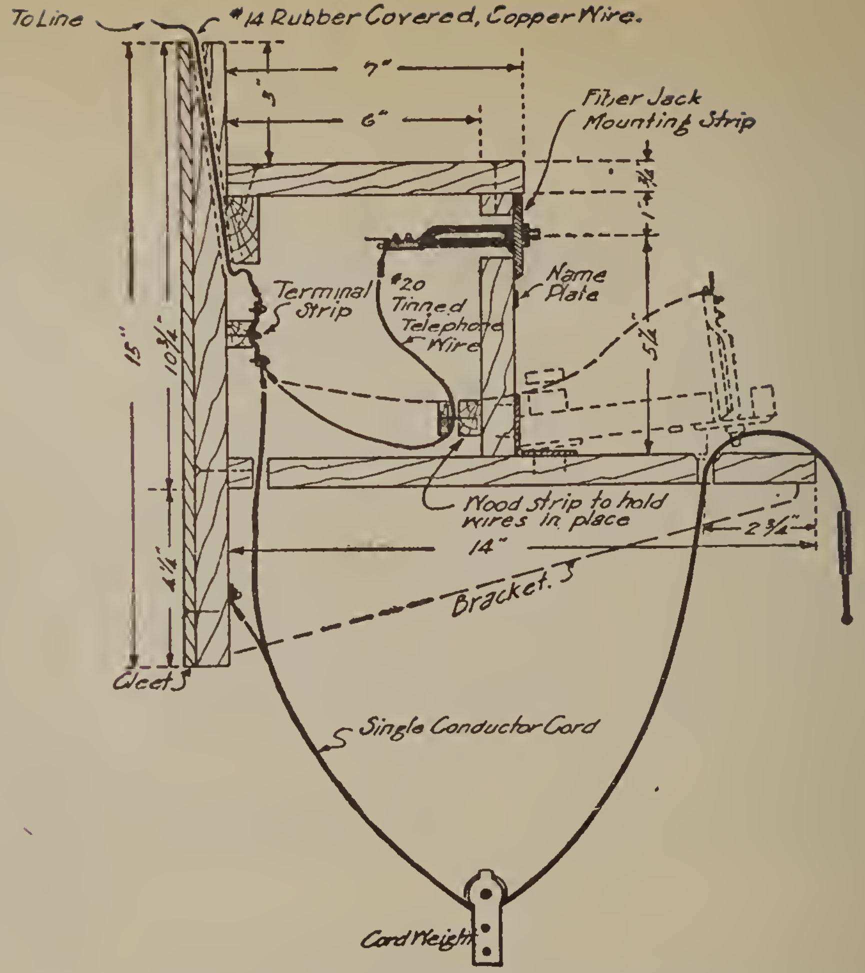



FIG. 62.—Section of board, showing location of equipment. The name plate to be located directly below each jack (and key), as shown in Figure 44. If extra head phone receivers are not desired, the right-hand jack is not needed

a howler connected to a line at any station where it is desired to receive signals from the Adams portable telephone or from the howler set. (See figs. 70 and 71.) As the resistance of the coils in a howler is only 1,000 ohms, it is necessary to connect a condenser in series with it in order to prevent its being a load on the line to which it is connected. Two makes of howlers are shown in Figure 68. The Western Electric howler and the condenser, except at San Francisco, are purchased separately and wired together on the job. The Kellogg howler and condenser are furnished, mounted, and wired up as shown, on a wooden base, and no adjustments are necessary. While the "Western" howler gives a louder tone, the Kellogg howler is loud enough for an average room, and much cheaper.

The Adams portable telephone can only be used to signal a howler. The howler, as explained above, is a high-resistance

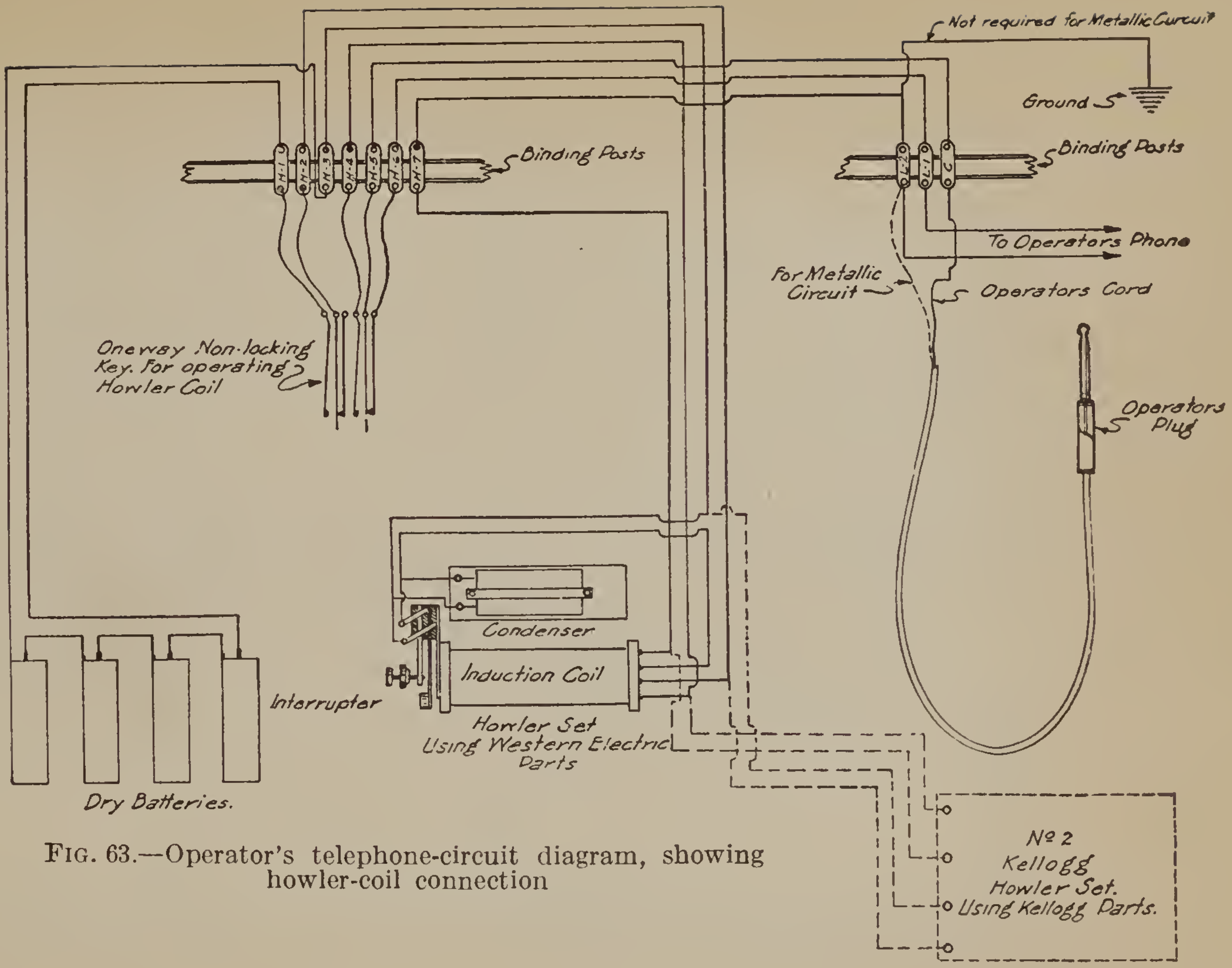



FIG. 63.—Operator's telephone-circuit diagram, showing howler-coil connection

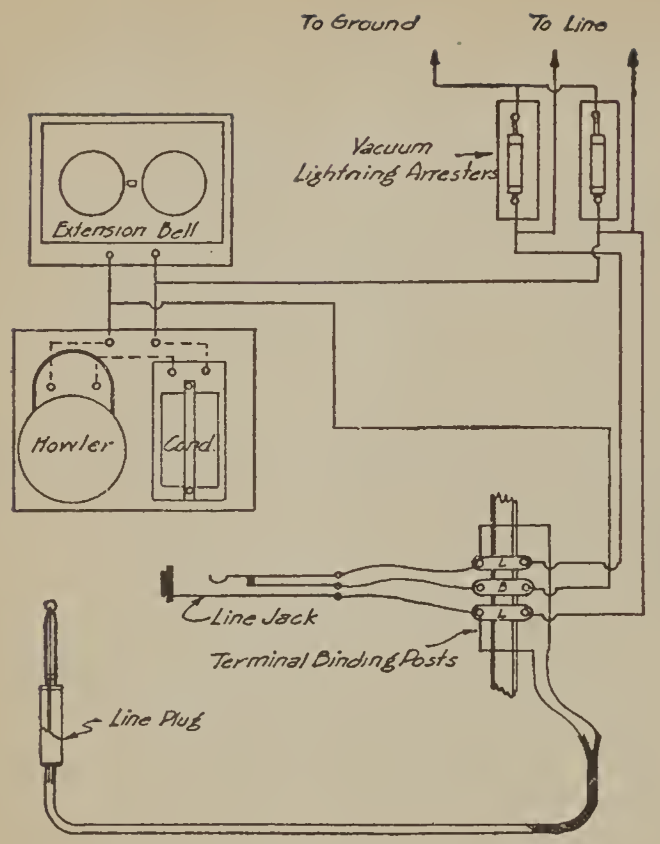



FIG. 64.—Line-circuit diagram, metallic circuit.
Wiring the same for each line

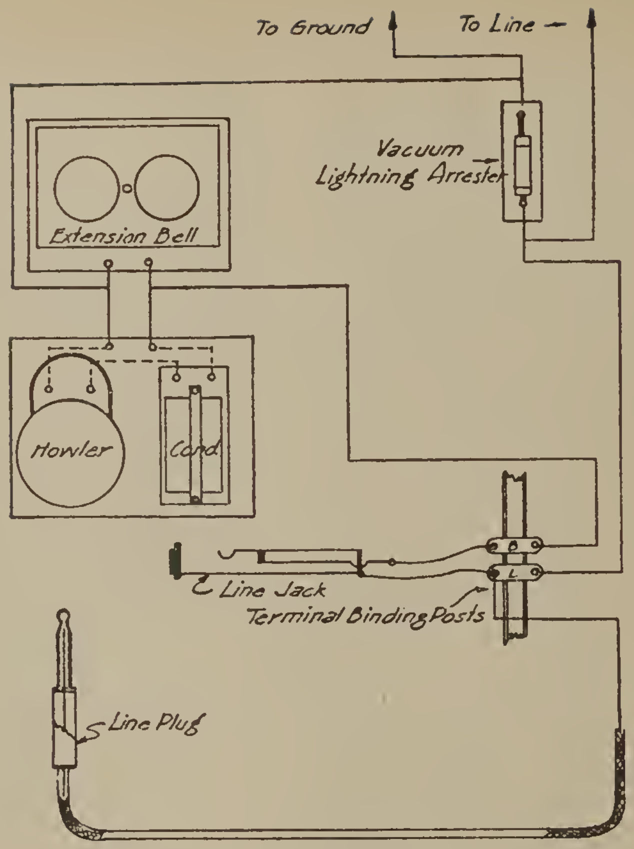



FIG. 65.—Line-circuit diagram, grounded circuit.
Wiring the same for each line

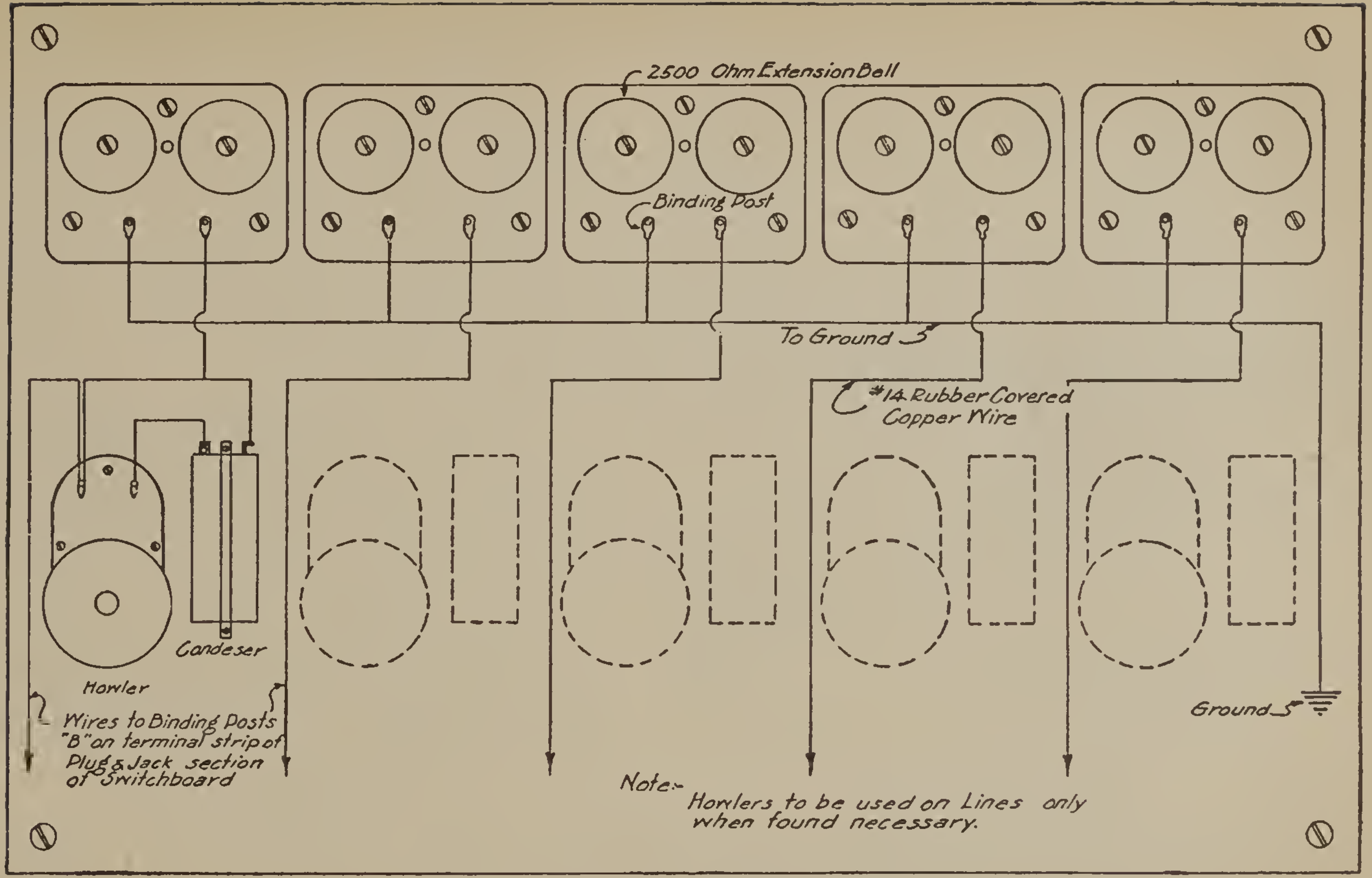



FIG. 66.—Bell and howler section

receiver with a small megaphone attached. Instead of having a permanent adjustment, as in a telephone receiver, the diaphragm is capable of being moved close to or a distance away from the permanent magnets.

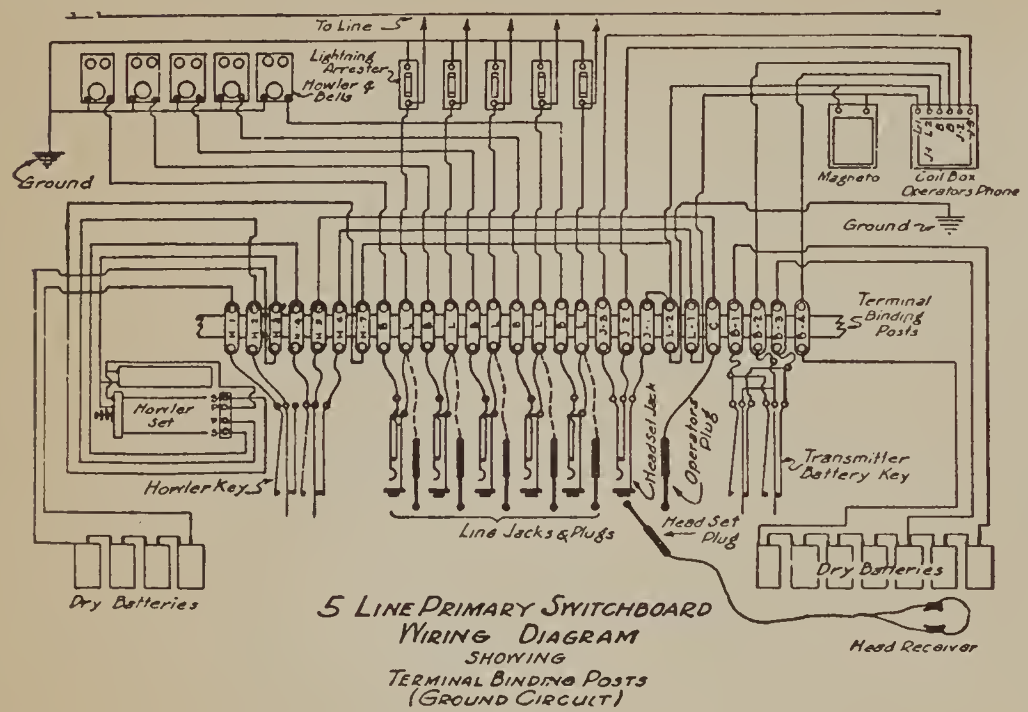



FIG. 67

**Adjusting the Western Electric Howler.**

Great care should be used when adjusting this howler in order to obtain the loudest tones possible. On the old type it is necessary during adjustment to tighten up the lock ring nut, so that the diaphragm, which is attached to the top ring, can not move closer to or away from the magnets. On the new type the diaphragm is automatically locked during adjustment.

**Howler Troubles.**

The only troubles that are likely to occur are either a burned-out coil in the howler or the condenser burned out. Lightning is the principal source of this trouble. If a howler fails to "howl," first check the adjustment (if it is a Western Electric howler), then "short" the condenser (connect both condenser wires together) and test. If the howler then works, put in a new condenser. If not, it indicates that the fine wire in one of the coils in the howler is probably burned out. This will necessitate changing the coils.

**Howler Set (or Howler Coil).**

With the howler method of calling instead of a magneto generator, an induction coil with an interrupter connected to a suitable battery producing a high-frequency current similar to the "Adams portable telephone" (see p. 75) is used for sending out a call signal, and a howler (see "Howler," p. 73) is used for receiving the

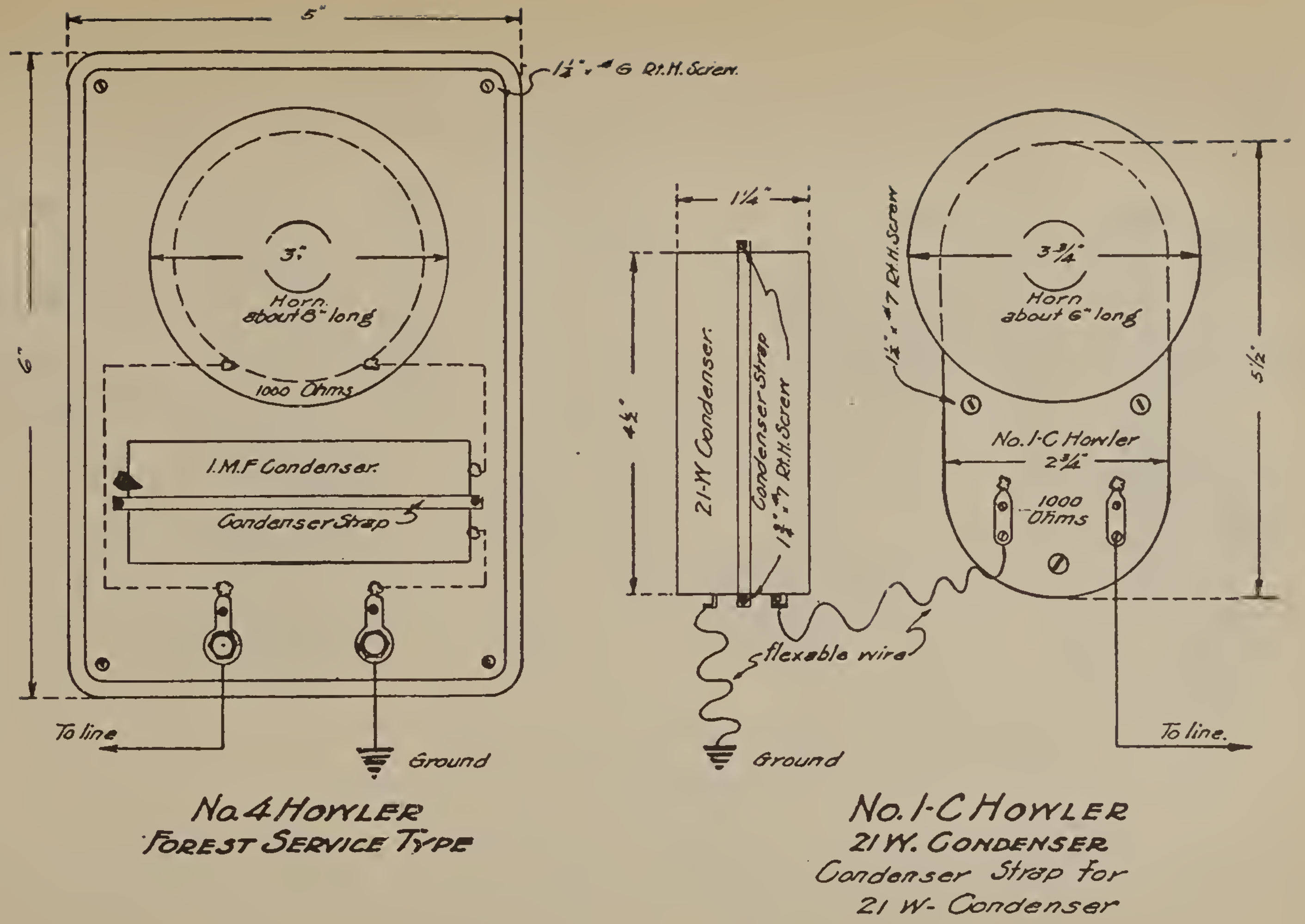



Fig. 68.—Two types of howlers

signals, instead of the regular ringer. On account of the nature of the current produced and sensitiveness of the howler, this method may be used satisfactorily on lines that are so long or heavily grounded that bell signals will not go through. Instructions for making a howler set for producing this high-frequency current suitable for installation at a telephone station or in a switchboard are given in Figures 70 and 71.

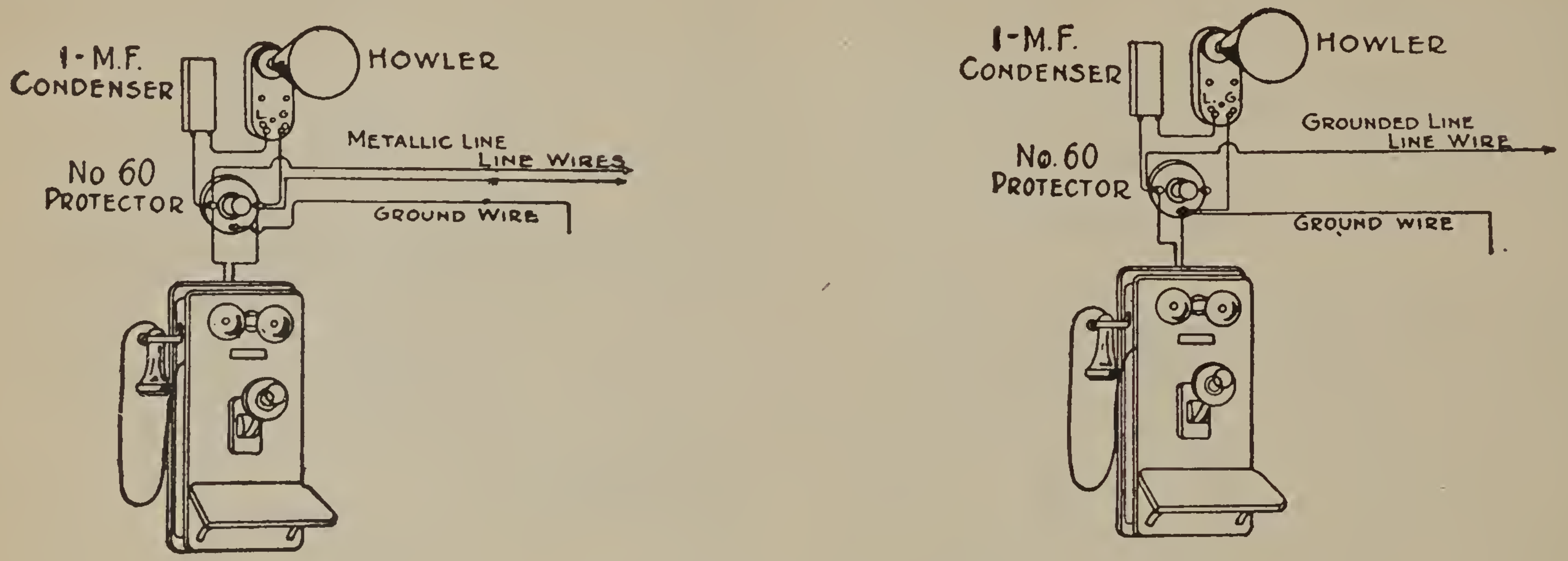



FIG. 69.—Howler connections

## "PHANTOM" CIRCUIT

When two metallic circuits that are well balanced (each wire of the same material, size, resistance, etc.) are on the same poles, it is possible with the use of two repeating coils to obtain a third circuit without stringing additional wires. The two original circuits are called physical or real circuits, and the third a metallic phantom or derived circuit.

LIST OF PARTS.

1-Standard No. 2 Kellogg Howler Set
- Induction Coil
- Interrupter
- Condenser
- 4 Binding Posts
- Wood Base.

1- #1033 Non-locking Key
5 ft. #20 tinned telephone wire.
5 #11 Binding Posts
Rosin Core Solder
Make Wood Base & Block for mounting key, on Job

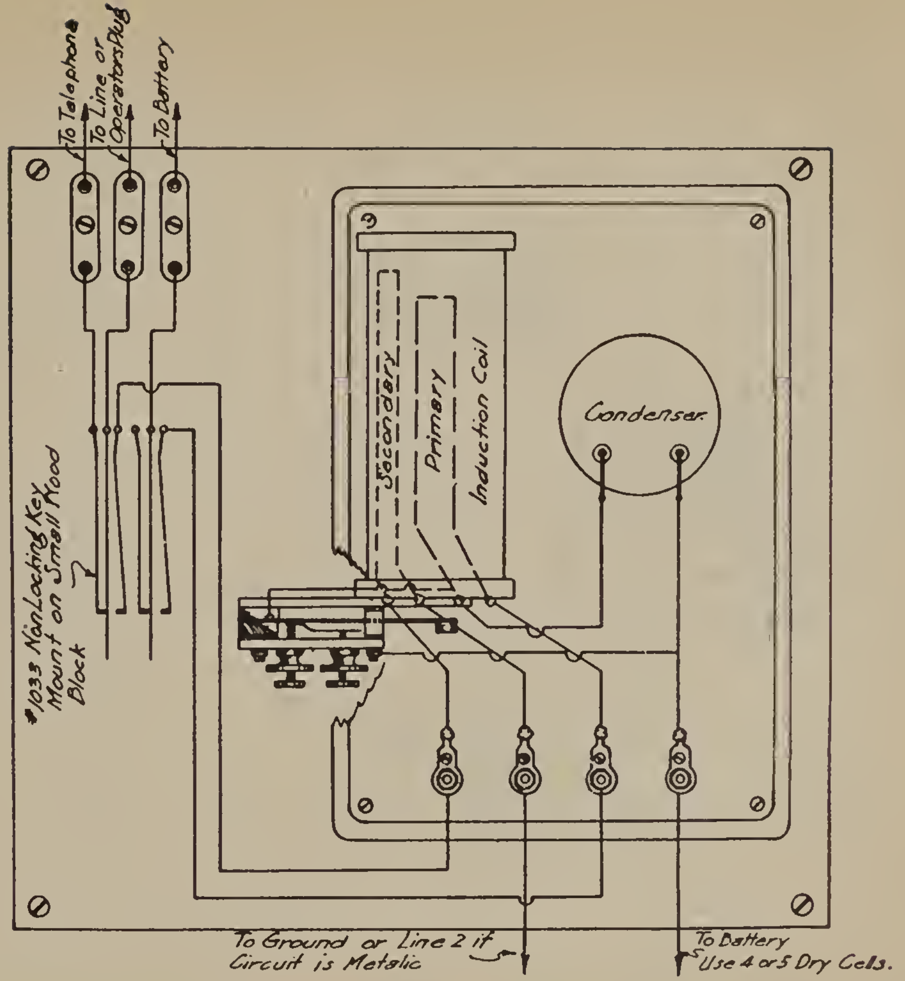
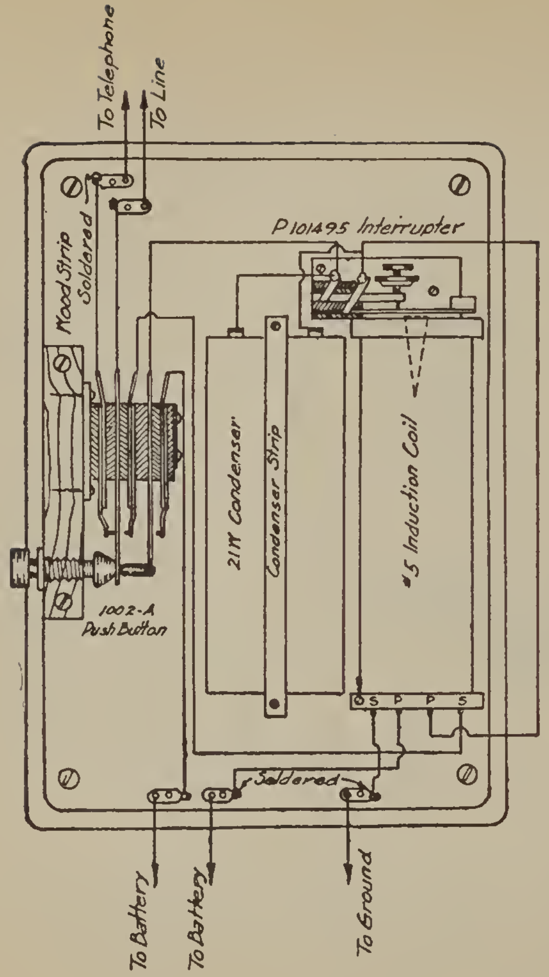



FIG. 70.—Forest Service howler-set wiring diagram. Kellogg standard parts




LIST OF PARTS

| | |
|---|---|
| 1 | Special No 5 Induction Coil |
| 1 | No P-101495 Interrupter |
| 1 | No 21-YY Condenser |
| 1 | Condenser Strap for Same |
| 1 | 1002-A Push Button |
| 5 | #P-36887 Binding Posts |
| 5 ft. | #20 tinned telephone |
| 2 - | 1¾ x 6 R.H. Screws |
| 2 - | 1½ " 6 " " |

Make base, & block for mounting Push Button, on Job.

FIG. 71.—Forest Service howler-set wiring diagram. Western Electric parts

When there is only one metallic circuit, it is possible to secure what is known as a grounded phantom circuit, using the metallic circuit and the ground, as shown in Figure 72. A ground phantom will be as "noisy" as a regular grounded-circuit line would be in the same location as the metallic-circuit line. However, a "cross" or broken wire in the metallic circuit will not affect the operation of the phantom circuit. Also, if the metallic circuit is well balanced (both wires of the same resistance) it will be possible to talk or ring over both circuits simultaneously with very little cross talk between them. Stub lines connected to the metallic line may unbalance the line enough to cause some cross talk. Wiring instructions for making connections on standard repeating coils for a phantom circuit are shown in Figures 42 and 43.

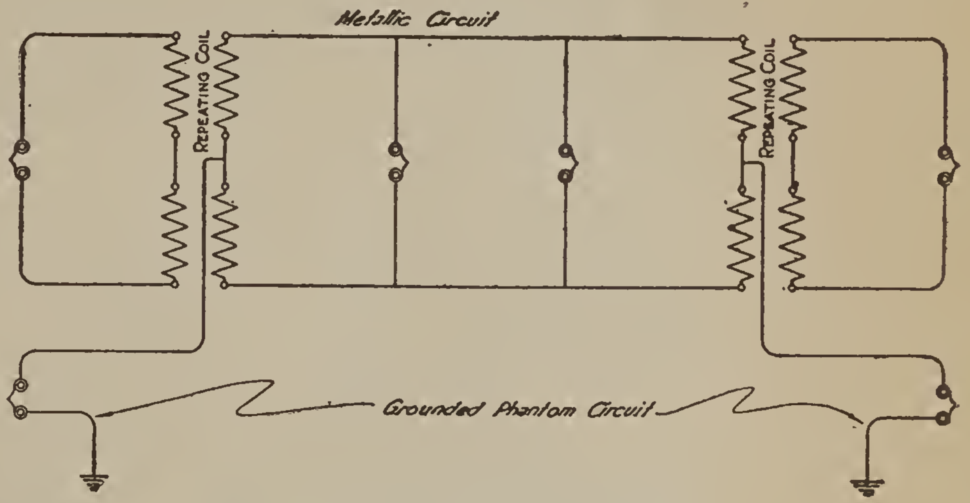


Fig. 72.—Phantom circuit

### PORTABLE FIELD TELEPHONES

No portable field telephone should be left connected to a telephone line continuously, as, for instance, at a trail or road camp, unless the resistance of the ringer-coil circuit is at least 2,500 ohms. The Adams portable telephone (see paragraph on "Telephone adjustments") is a very light instrument, suitable for talking on any line, but it can be used for signaling only on lines to which howlers are connected. As the resistance of the coils in this telephone are very low, it must be disconnected from a line when not in use. Otherwise it will make a heavy ground. At stations equipped only with portable, install a standard extension bell for receiving signals.

### SPECIAL TELEPHONES

There is occasionally a need of a telephone having a greater range (talking and receiving) than the standard telephone. This is on account of the unusually severe conditions (as noted below) under which is it often

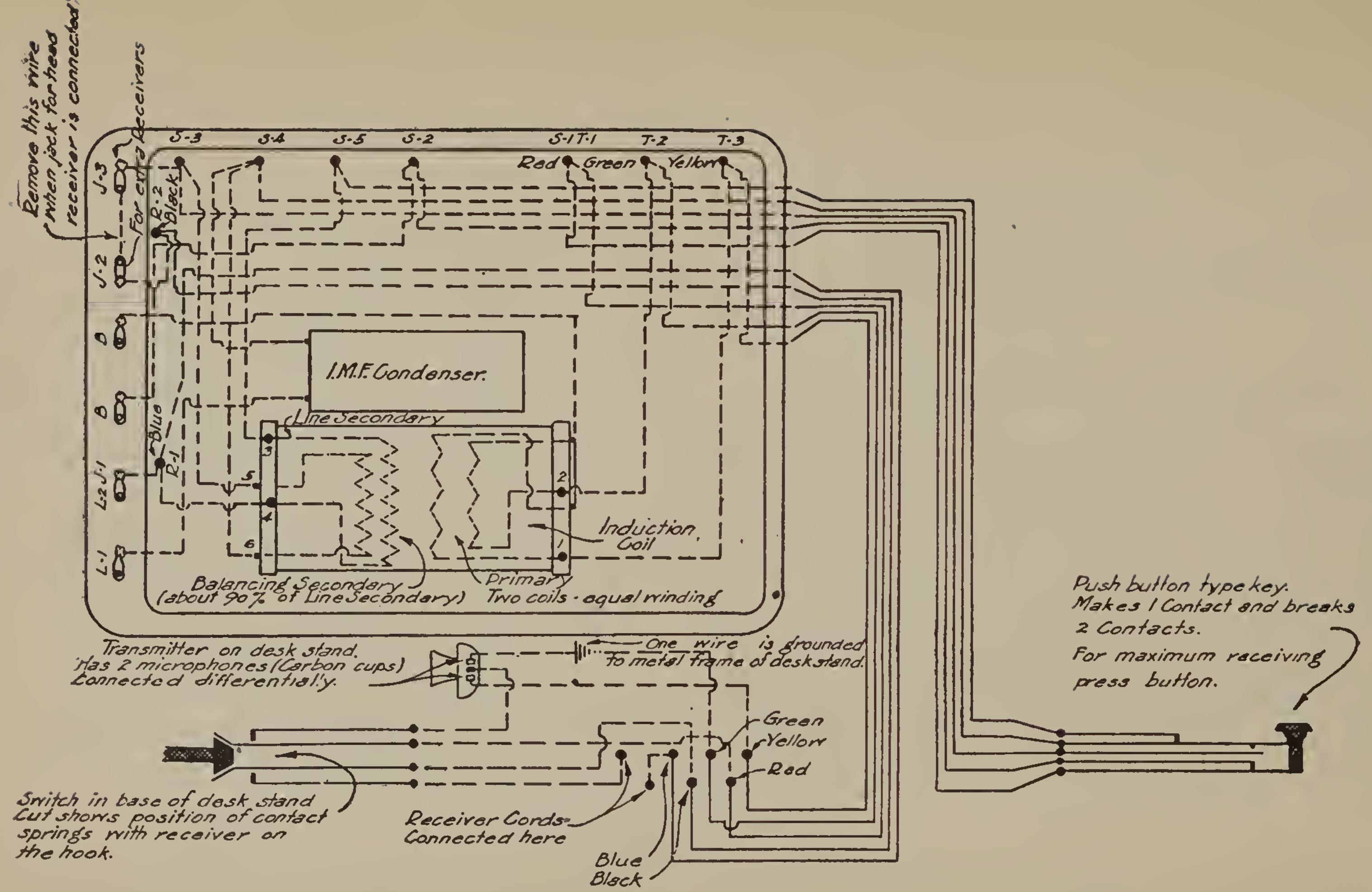



FIG. 73.—Dispatcher's desk set (Wonderphone) circuit diagram

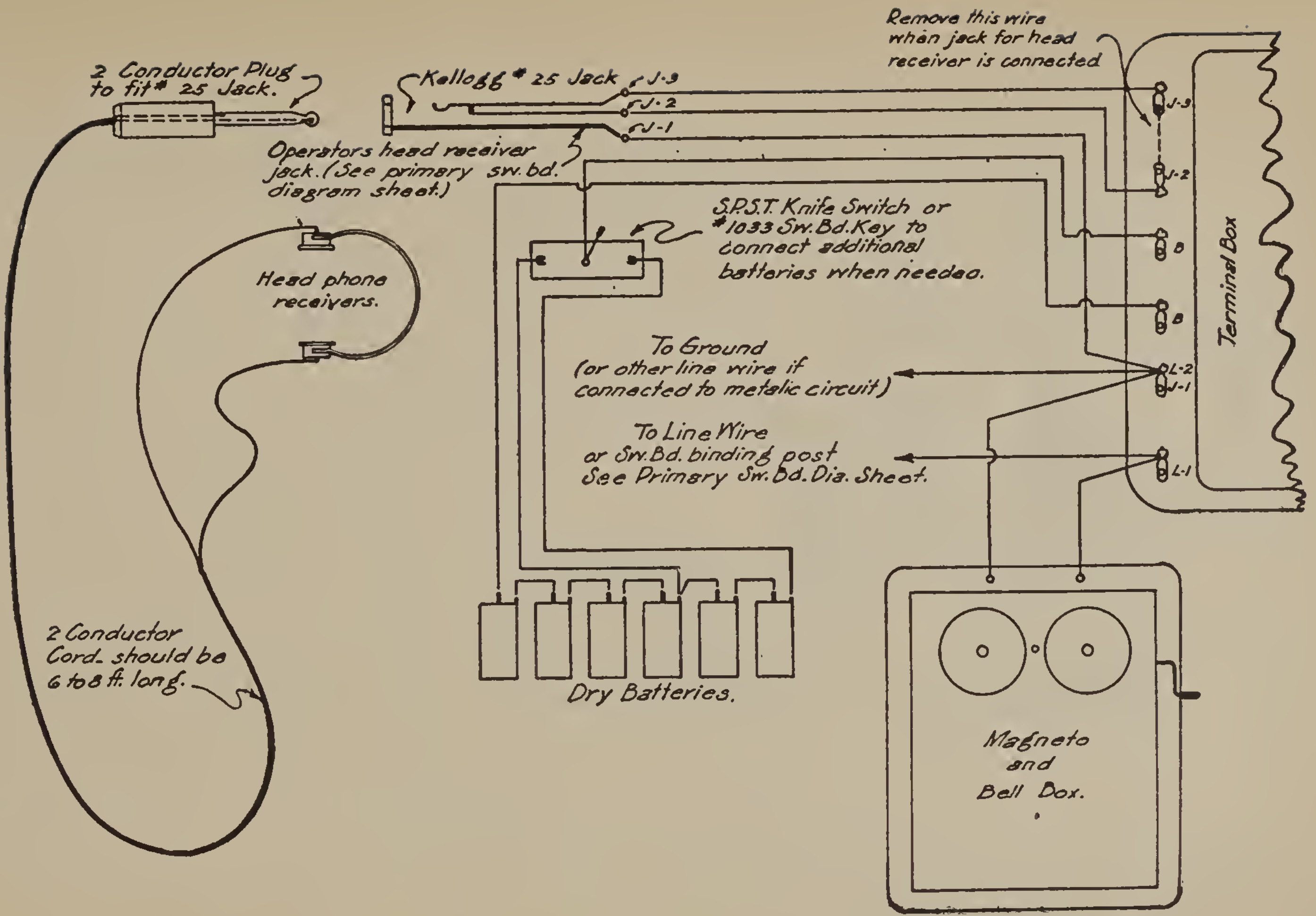



FIG. 74.—Dispatcher's desk set (Wonderphone) wiring for installation

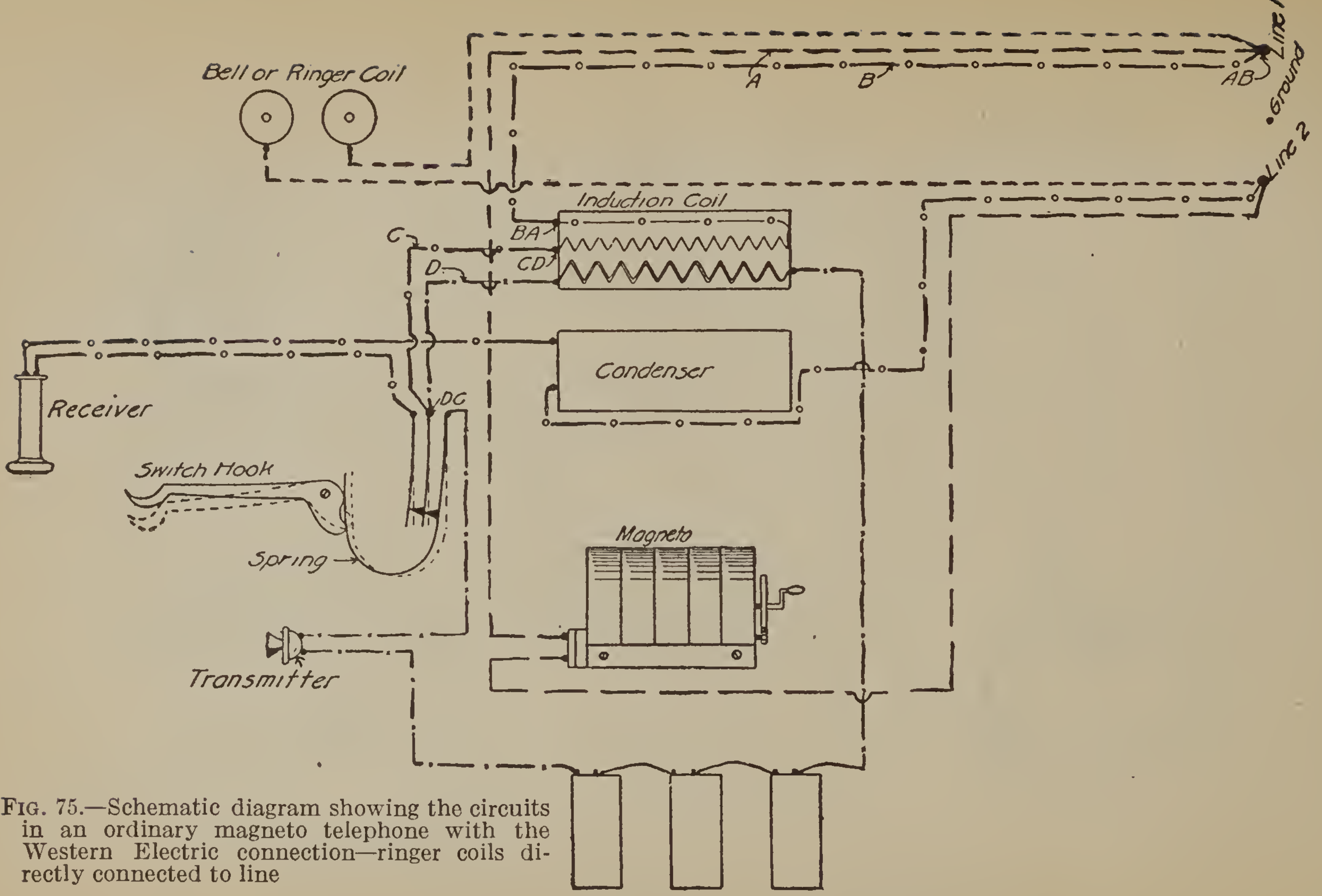



FIG. 75.—Schematic diagram showing the circuits in an ordinary magneto telephone with the Western Electric connection—ringer coils directly connected to line

necessary to talk over Forest Service lines. (Extreme length, 100 to 150 miles, "static" heavily (electrical) loaded line, account of many lines connected together or line leakage.) The Western Electric Co.'s train dispatcher's telephone set (wall set No. 1317BU and desk set No. 501) has given excellent results for use on such lines, particularly in regard to receiving. The Kellogg Switchboard & Supply Co.'s "Grab-a-phone" desk set has a very efficient transmitter with a good talking range, but with the regular receiver. Also there has been developed by the Universal High Power Telephone Co. a Forest Service type of a dispatcher's desk set which has a much greater range, both in talking and receiving, than the standard telephone. A circuit diagram is shown in Figure 73, and the wiring diagram for making battery, line, and extra head receivers is shown in Figure 74. The transmitter has two large microphones, as noted (instead of one, as in the standard telephone), and six cells of dry battery may be used. Three cells are enough when talking over the average line; therefore a switch should be provided to cut in three additional batteries when it is necessary to talk over long or badly grounded lines. This telephone is also very effective to "outtalk" the static on a line.

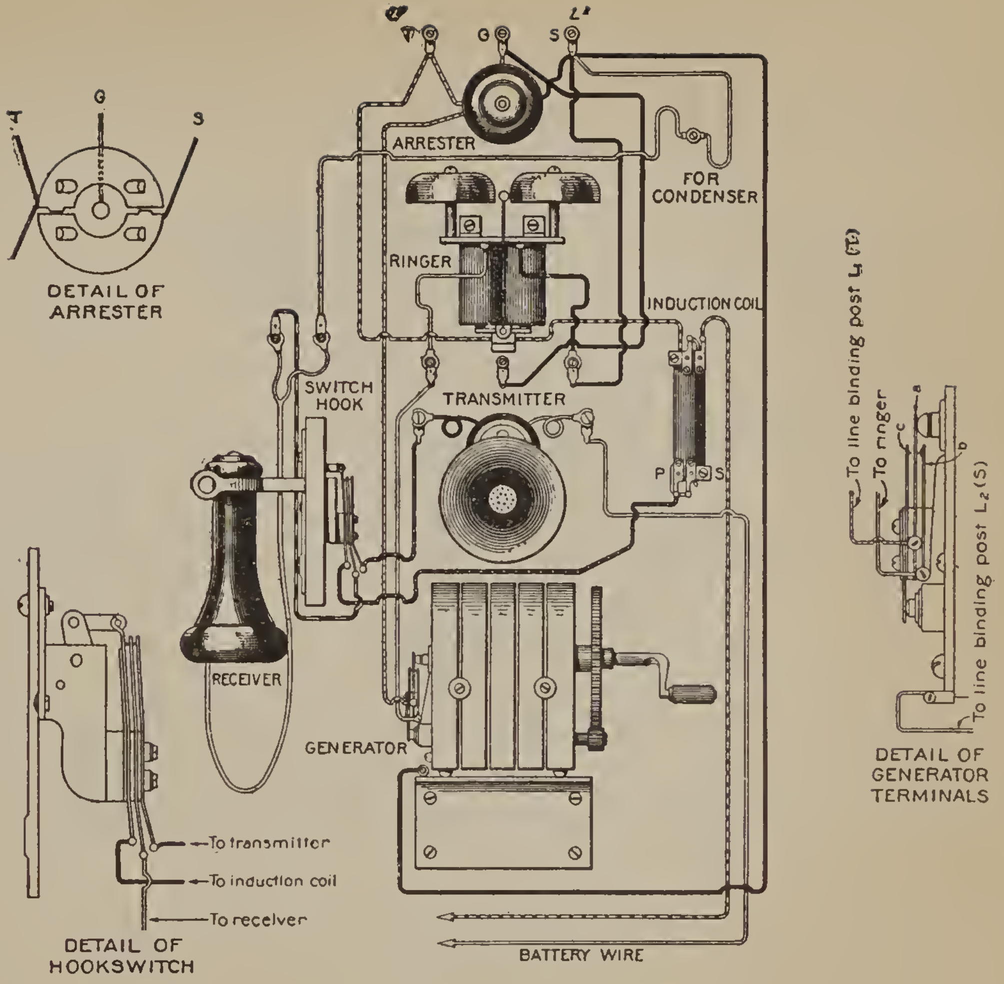



FIG. 76.—Kellogg telephone

## TELEPHONE CIRCUITS

The four circuits in a magneto telephone (see circuit diagram as shown in Figure 74, and descriptive diagrams of each circuit as shown in Figures 77, 78, 79, and 80) are as follows (the Kellogg ringer circuit, which is different from the Western Electric, is shown in Figure 76):

(1) The bell or "ringer" circuit (figs. 77 and 78) includes only the ringer coils.

(2) The magneto circuit (figs. 75 and 77) includes the magneto (generator).

(3) The receiving circuits (figs. 75 and 80), sometimes referred to as the secondary circuit, include the receiver, the hook switch upon which the receiver hangs, the condenser, and the secondary or fine winding in the induction coils.

(4) The transmitter circuit (figs. 75 and 79), sometimes referred to as the primary or battery circuit, includes the batteries, hook switch, primary or heavy winding in the induction coil, and the transmitter. This circuit is not directly connected to the line.

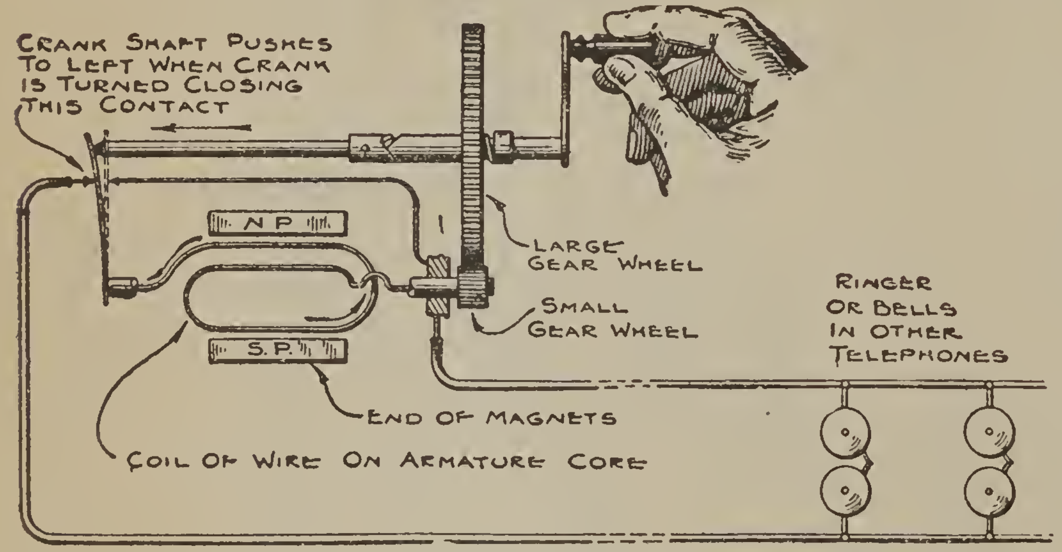



FIG. 77.—Magneto. Diagram illustrating the principle of the operation of the magneto. The strength of the ringing current is increased to some extent by turning the crank more rapidly. The current thus generated alternates or reverses in direction once for each turn of the crank (from 16 to 20 times a second)

Vibrations in transmitter diaphragm, set up by the voice sound waves, compress the pulverized carbon in the small cup attached to the back of the diaphragm with varying degrees of intensity. This changes the resistance of the transmitter circuit, resulting in electric-current variations, corresponding to the sound-wave variations.

The current variations set up by the transmitter pass through the primary windings of the induction coil (see fig. 79), which induces a similar varying current with a greater pressure in the secondary winding. This

current passes through the line wire to the receiver at the receiving telephone. These variations of electric current produce changes in the magnetic strength of the receiver magnets. This alternately attracts and repels the receiver diaphragm, causing it to have a vibration similar to that imparted to the transmitter diaphragm by the sound waves and reproduces the sound.

## TELEPHONE TESTING AND ADJUSTMENTS

### RINGER (BELL)

The same type of ringer is used in both telephone and extension bells. The operating principle and most important adjustments are the same for practically all makes. (See fig. 82.) All ringers contain two gongs with adjusting screws, two spools of fine wire with iron cores forming the electromagnets, a pole piece or armature suspended at its center in front of the ends of the electromagnet cores, the tapper rod attached to the armature, a permanent magnet for magnetizing (polarizing) the ends of the armature, and the frame to which the above parts are attached. (See fig. 82.)

There must be the following adjustment of these parts in order to secure proper results: The ends of the armature (to which the tapper rod is attached) should have a movement of about $\frac{3}{32}$ inch back and forth in

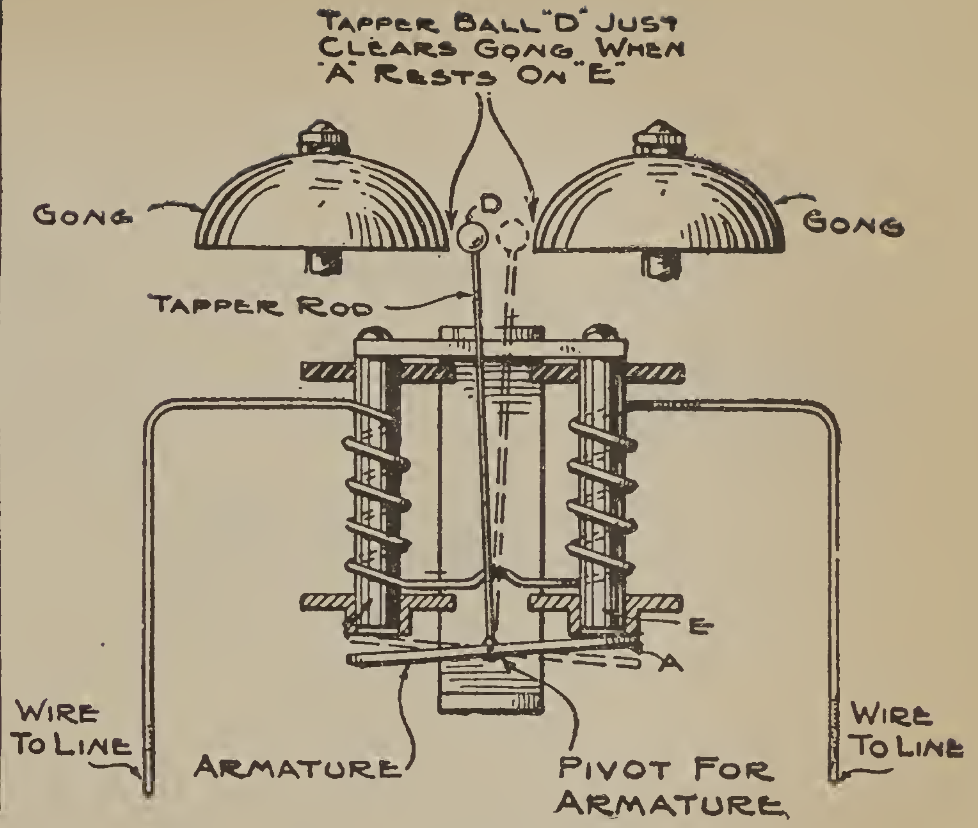



FIG. 78.—Ringer. As the ringing currents alternate in direction, the magnetism in the ringer coils is reversed, alternately pulling first one end of the armature and then the other

front of the ends of the electromagnets, a little more for short lines, less for long, heavily loaded lines. In Western Electric ringers this adjustment may be changed by turning screw "*c*" (fig. 82) in or out. Some Kellogg ringers have nuts on the ends of the magnet cores for making this adjustment. The armature is suspended by two points, the front one being held in position by an adjustable screw "*n*." This screw should be just tight enough to hold the pivots in place, allowing a free movement of the armature but without any lost motion. Its point must be sharp to prevent its sticking. If necessary to make a new adjustment, loosen lock nut "*e*" and turn adjustment screw until above results are secured. Be sure, however, when the lock nut is tightened again that the adjustment screw does not turn.

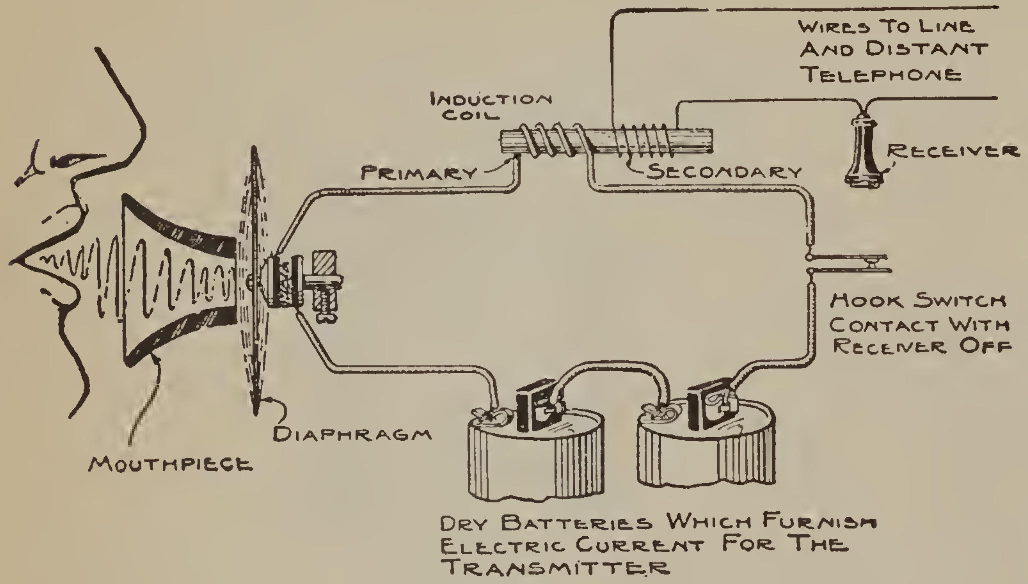



Fig. 79.—Talking

The gongs "*k*" should be set so that the tapper ball just strikes the gong, but does not "hang" to it without rebounding. To change adjustment, loosen set screw "*a*" on the back and turn adjusting screw "*b*" to the right or left according to the direction it is desired to move the gong.

Ringer trouble may be caused by a wrong adjustment of parts just described, or the fine wire in the coils "*f*" and "*f*" may be burned out by lightning. To determine this, make test for Western Electric telephone as follows: Hang the receiver on the hook and disconnect the line wires. Then turn the magneto crank; if the bell does not ring, moisten the tips of fingers and touch them to the bare ends of the ringer coil wires "*x*" and "*y*" (fig. 82) and turn crank. If no current is felt (and the generator is operating properly), the wire between the bell and the magneto is probably broken. Make the next test by placing the finger tips on line binding posts "$L_1$" and "$L_2$." (See fig. 83.) If the current is felt here, look

for a broken wire between this point and the ringer coils. It might be, however, that the bells were so out of adjustment that even if current were felt the bell would not ring. If, on the other hand, current is felt at the first test, it shows that either the ringer adjustments are wrong or the wire is burned out in one or both of the coils.

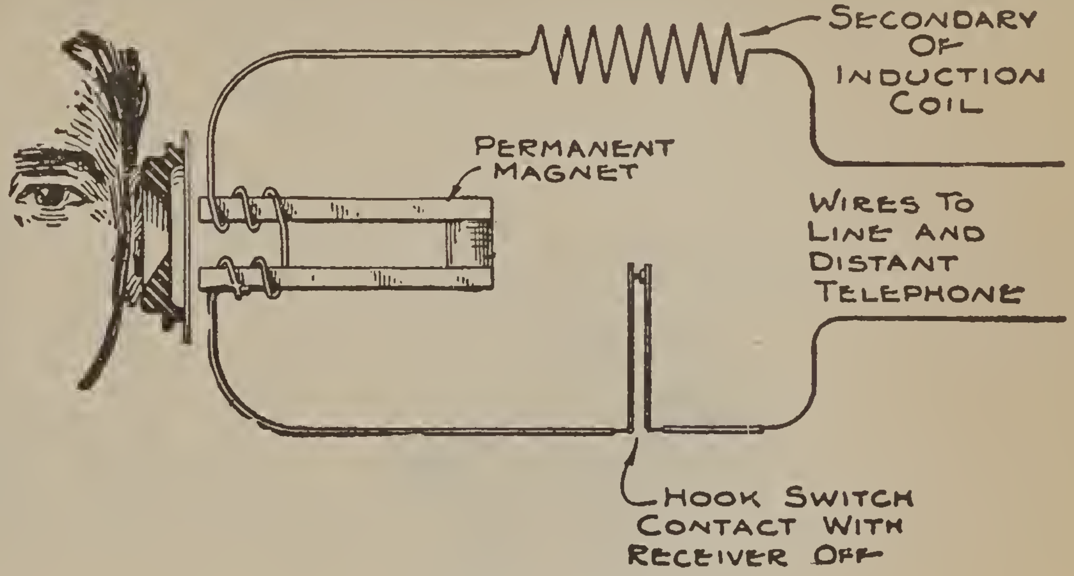


FIG. 80.—Receiving

In the Kellogg telephone, one ringer coil wire is connected directly to the line binding post, and the other one is connected to the other line binding post through the back contact on the magneto contact assembly, as described in Figure 76. Therefore to test the ringer coils as previously described it will be necessary to make a short circuit between contact springs "*a*" and "*b*" (fig. 59a) while turning the crank. This may be done by inserting a knife blade or small screw driver between the two springs.

Check the adjustments and if they are all right test the ringer coils by connecting them one at a time to "*a*" and "*b*." (Fig. 86.) If there is no click in the receiver when the connection is made, it indicates the coil is burned out. In this event take the ringer coils out of frame and substitute good ones. This should not be attempted, however, unless soldering outfit is at hand. Better to have a few extra complete sets, including ringer frame and coils, available, except gongs and nuts. One of these sets can be substituted easily and a good coil put in the old frame when convenient. However, it may be possible to make temporary repairs by removing the paper cover from the coils and connecting the burnt ends of the fine wire.

(See schematic diagram in fig. 77.) This is merely a type of a dynamo having permanent magnets in horseshoe shape and an armature consisting of a single coil wound on a round piece of iron for a shaft. The action of turning the crank causes the armature to revolve between the ends of the magnets, producing an electric current

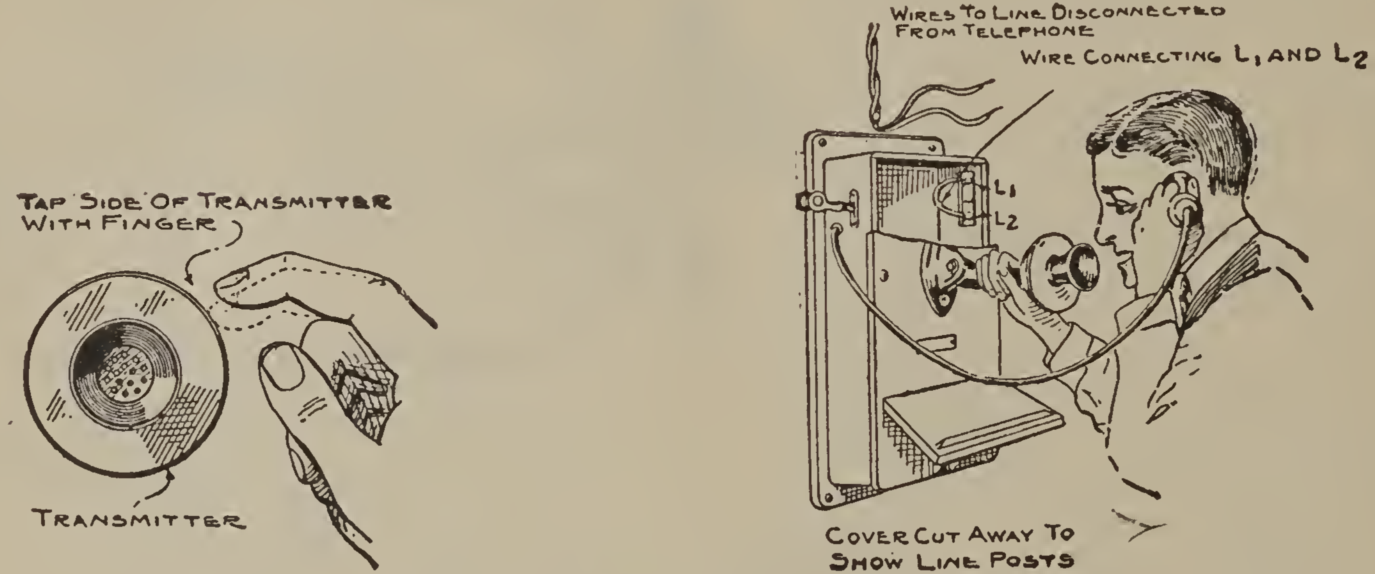



FIG. 81.—Testing the transmitter

in the armature coil. One end of this coil is connected (grounded to the metal part or frame of the magneto). The other end is connected to an insulated conductor through the center of the armature shaft (which is hollow) to the left end ("*F*" in fig. 84) and makes contact with an outside spring "*E*." This is not connected directly to the line wire, but when the crank is turned the crank shaft is forced to the left by a coil spring in the shaft, pushing the upper end "*c*" of the spring against the line contact. This completes the ringing circuit, as the

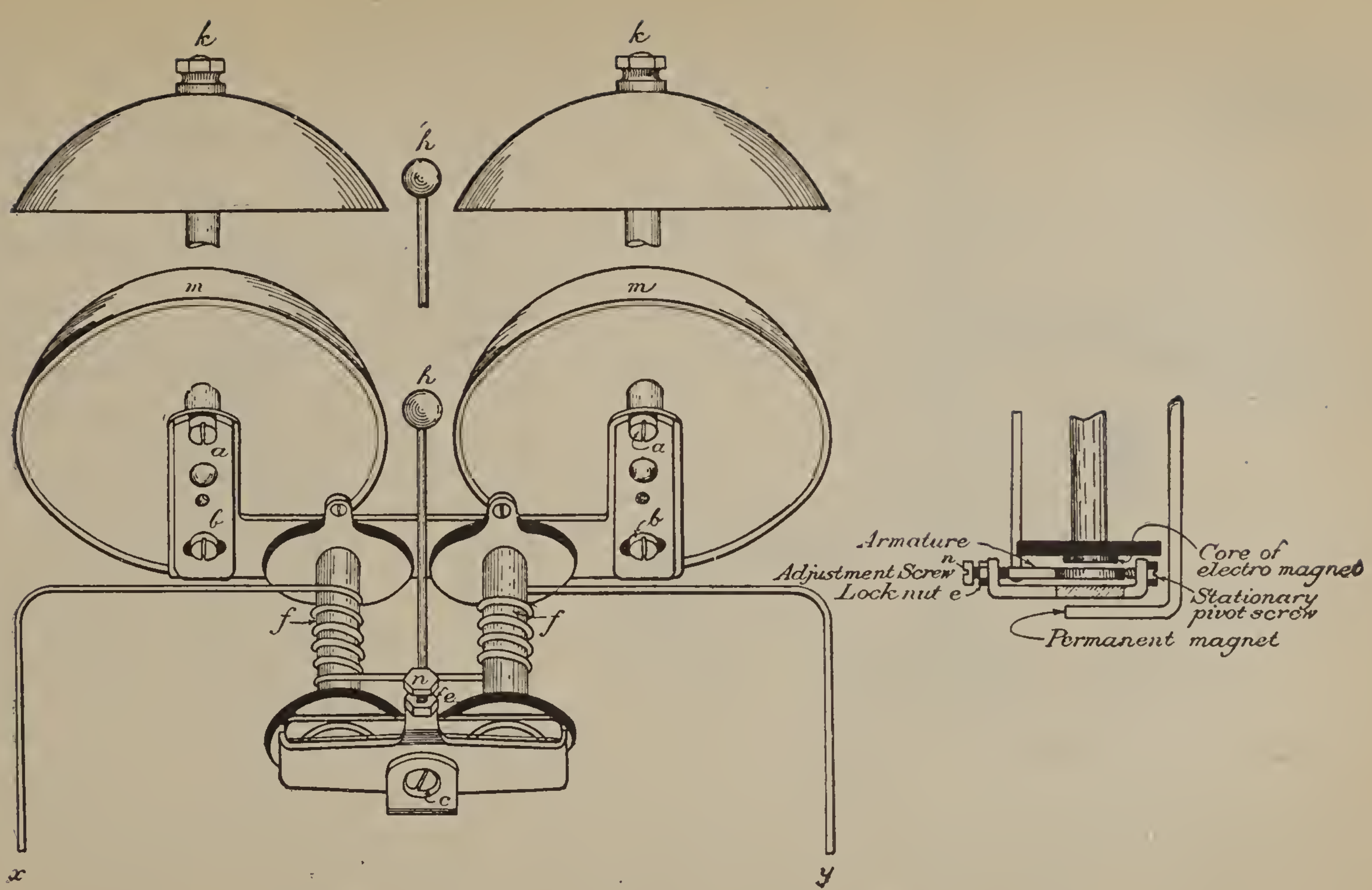



FIG. 82.—Construction of 38 B-G (Western Electric) telephone ringer

ground wire is connected to the other end of the armature coil through the frame. The sliding action of the crank shaft connects the armature coil to the line when the crank is turned and breaks the connection when the turning motion is stopped, thus keeping the generator disconnected from the line when it is not in use. This is necessary because the resistance of the armature coil is low enough to cause a ground on the line if it is left connected at all times. In the Kellogg telephone the action of the magneto spring contacts is as just described for the Western Electric telephone, except that the ringer connection which is made between contacts "*a*" and "*b*" (see fig. 76) is broken when the generator crank is turned, as the action of turning the crank causes the crank shaft to slide forward to the left.

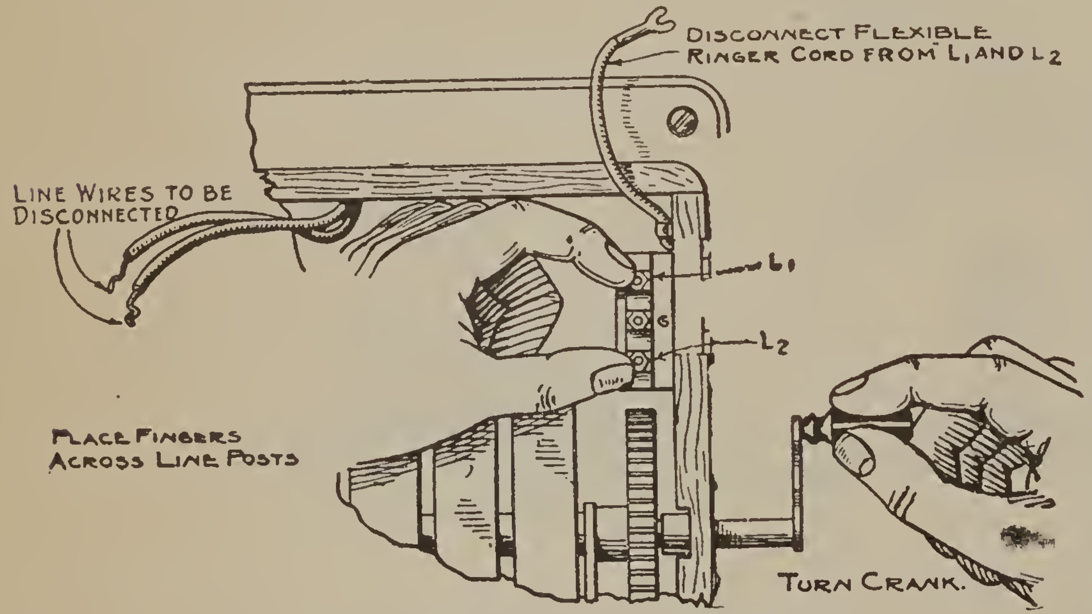



FIG. 83.—Testing magnets with the fingers

Make generator (magneto) test as follows: Be sure that the receiver is on the hook, then disconnect wires "*x*" and "*y*," as shown in Figure 84. Place the moistened fingers across the screw contacts "*x*" and "*y*" and turn the crank. If a very decided stinging sensation or shock is felt in the fingers while it is being turned, this indicates that the generator is operating and is probably all right. If, on the other hand, there is no stinging sensation or shock felt, or it is very slight, there is trouble in the generator, and it will be found that it is either open or short circuited. If open, the crank will turn easily; if short circuited, the crank will turn hard. If the crank turns hard, the trouble in all probability is a short circuit in the rubber bushings separating the spring contacts (*c*, *b*, *f*, *d*, fig. 84). This is usually caused by lightning. It may, however, be caused by too much oil. If such is the case, there will probably be an odor of burning rubber. In order to be sure that this is the trouble, it will be necessary to take the generator out of the telephone and remove the entire spring-contact assembly

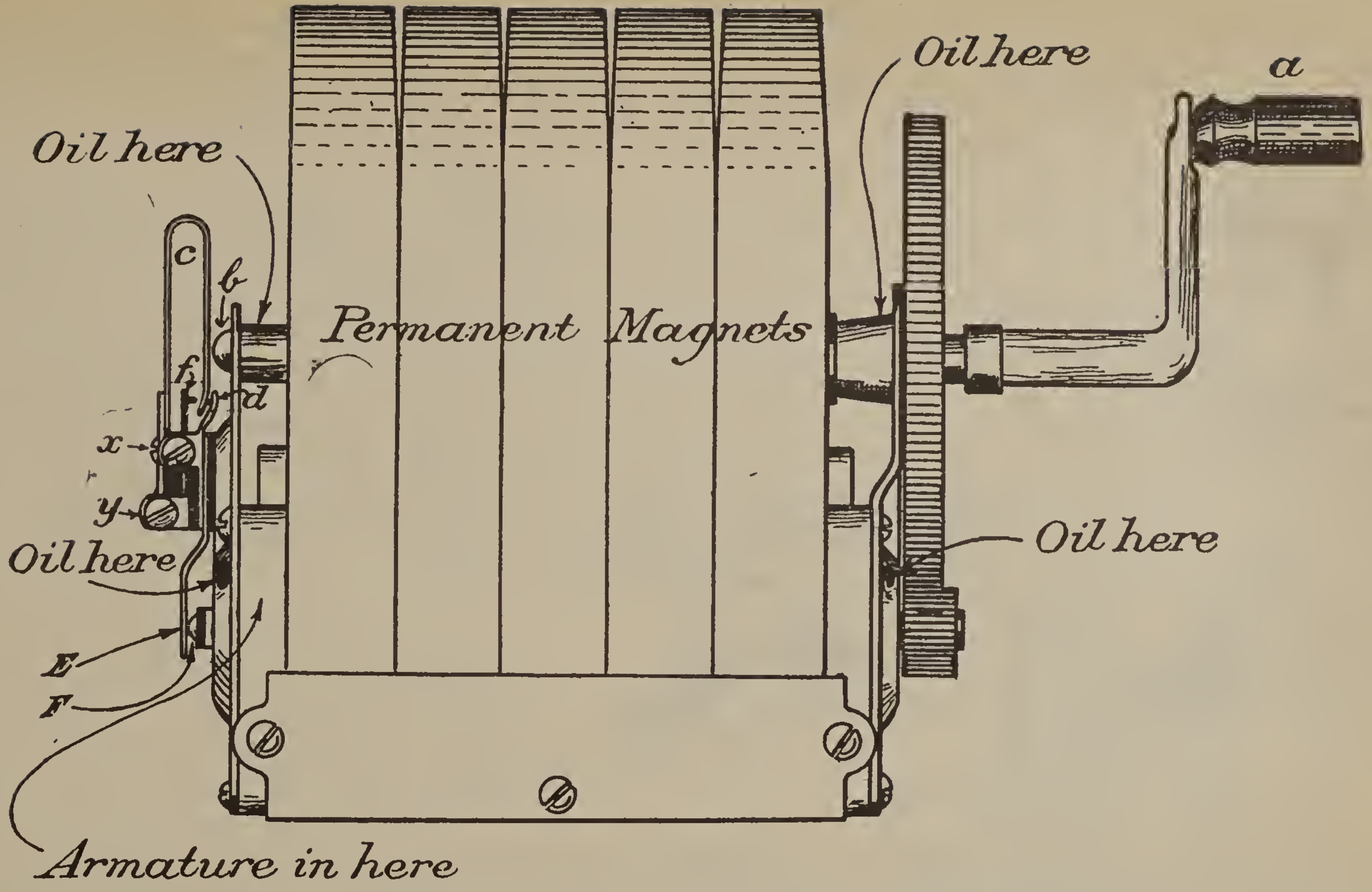



FIG. 84.—The magneto-contact assembly includes all of the springs, contacts, binding screws, and insulation material shown at the left end of the magneto in Figure 84. The entire assembly is removed by taking out the two end screws (not shown in this cut)

(see figs. 78 and 84) by taking out the two end screws. Do this carefully, for if the trouble is not here the springs and insulating strips must be put back exactly as they were. Then turn the crank; if it still turns hard, the trouble is in the armature, either a "short" (in which event a new armature should be secured) or mechanical trouble at the bearings, which usually can be corrected with a few drops of typewriter oil. If the crank turns easily, the trouble is in the spring-contact assembly. In this event the entire assembly should be replaced. It is advisable usually to have an extra complete "magneto spring-contact assembly" on hand. If a new assembly can not be secured, it may be possible to make repairs on the job. Take the old assembly apart, locate the defective insulating, bushing, or flat strip, and scrape off the carbonization carefully. (A thin piece of shellacked cardboard may be substituted in an emergency.) Then replace the parts, being sure to wipe each piece clean first and to get them back exactly as they were.

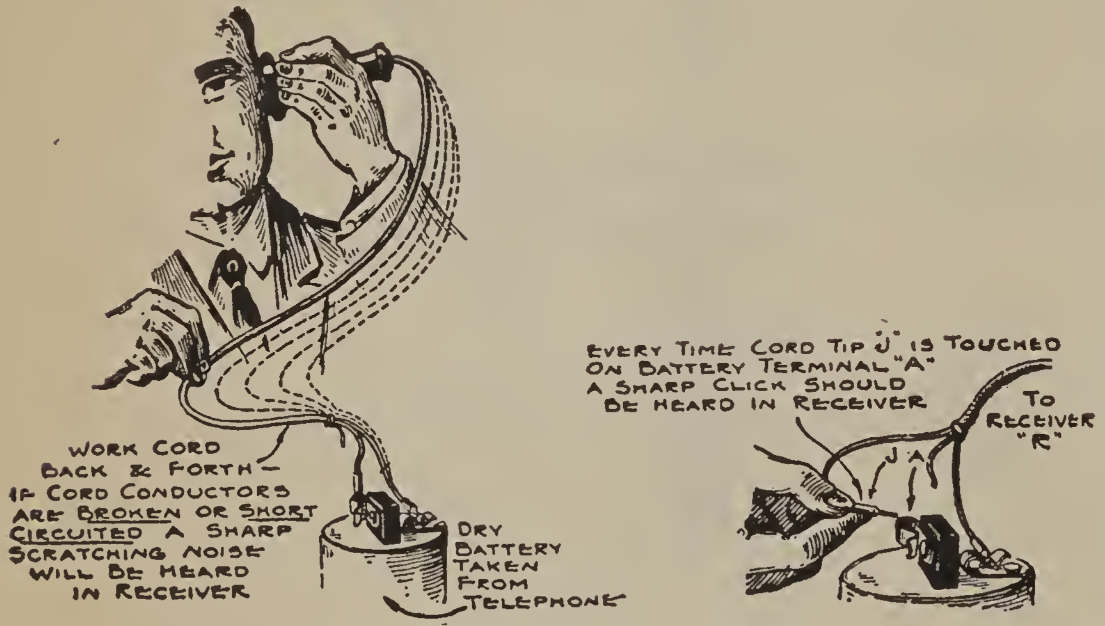


FIG. 85.—Testing the receiver cord

It sometimes happens that the permanent magnets on the generator become weak after long usage. This will be indicated by a reduction in the amount of current the generator gives. If the generator produces only a feeble current when the crank "*a*" is rapidly turned, it is a clear indication of weak magnets. If such is the case, either a new set of magnets is necessary, a remagnetizing of the old magnets, or the replacement of the entire generator. Sometimes the generator is weak because some one has taken it apart and replaced a magnet incorrectly. Each magnet has a punch mark on it, and these punch marks should face the back of the generator. If the magnet is reverse, the strength of the generator will be greatly reduced. The magneto

should be oiled occasionally by putting a drop or two of typewriter oil in each oil hole, as indicated in Figure 84.

## RECEIVER

The action of the receiver is described in Figure 80. There is only about a sixty-fourth of an inch clearance between diaphragm and the ends of the receiver magnet cores. It is important therefore that any dust or filings which may be inside the receiver be cleaned out; and if the diaphragm is dented, either reverse it or replace with a new one. If the receiver has been dropped, the magnets may be jarred out of place. In this event, or if the fine wire on the receiver magnets should be burned out by lightning, the receiver should be replaced with a new one. Convenient methods of testing a receiver or receiver cord are shown in Figure 85.

The receiver may also be used in making tests for broken wires, as shown in Figures 86 and 87.

## SWITCH HOOK

The switch hook is in both receiver and transmitter circuits. (See fig. 75.) Some makes of telephones have four springs, two for each of the transmitter and receiver circuits. The action is similar in either case. When the receiver is off the hook, all springs make contact; when it is on the hook, all should clear. If they do not clear each other when the receiver is on the hook, the battery will run down rapidly, as the circuit would be closed all of the time. Bend them a little if necessary

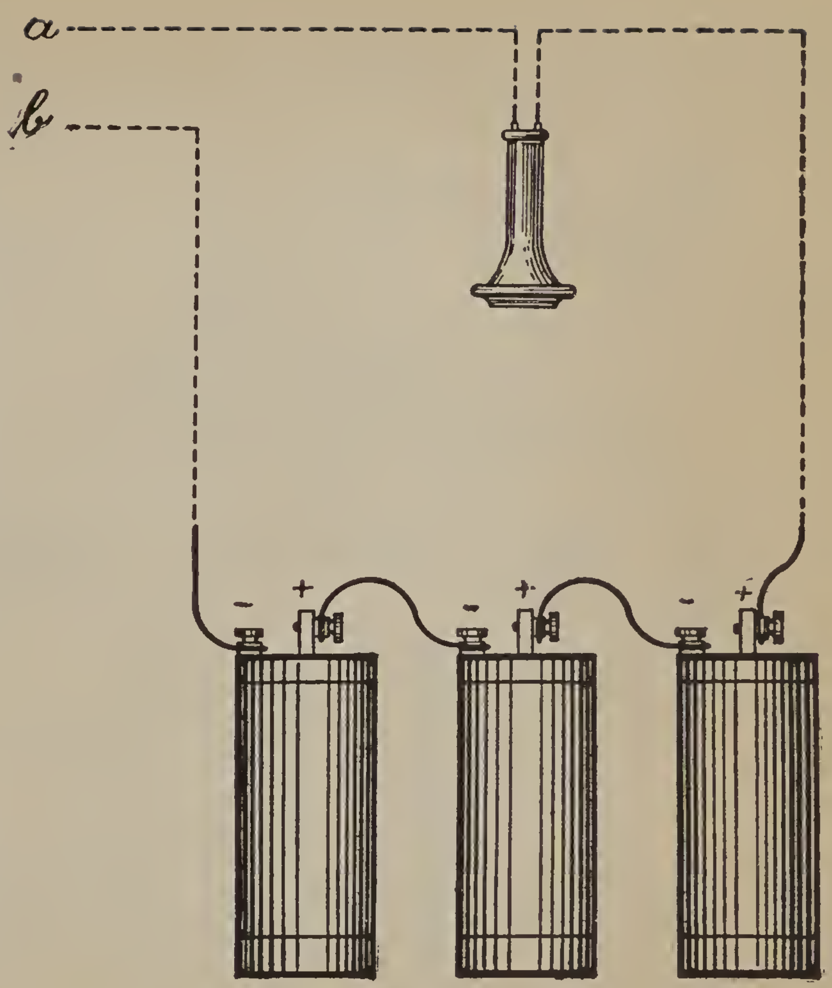


FIG. 86.—Receiver test for locating an open circuit. One battery will work

to secure the proper clearance. The insulation between these springs may also be injured by oil or lightning. (See "Magneto," preceding.) This will cause the battery to run down very rapidly. In this event the entire "switch-hook assembly" should be replaced with a new assembly.

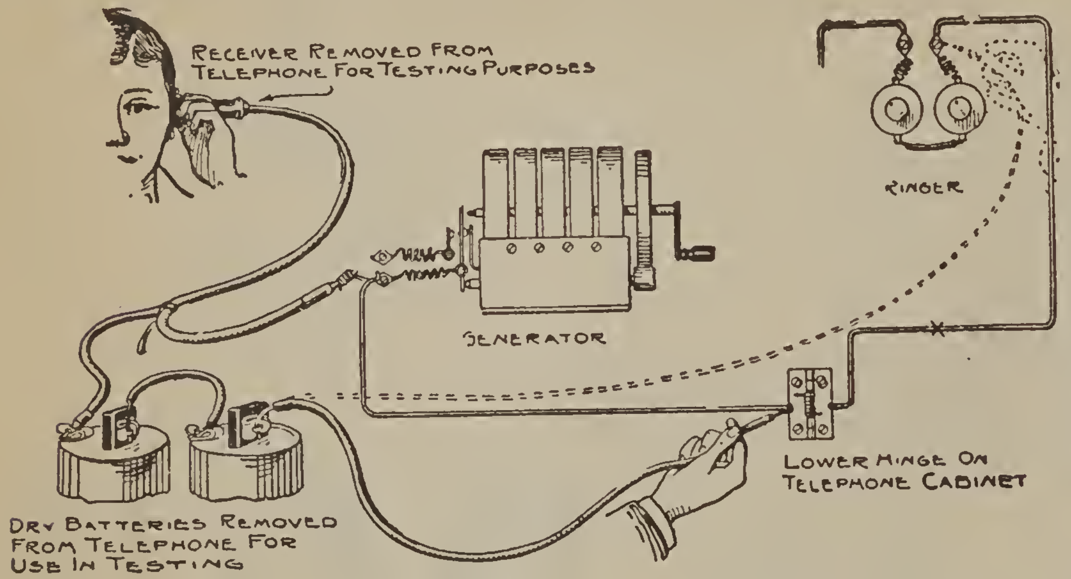



FIG. 87.—Testing for broken wire in generator circuit. This method may be used in testing for any broken wire

### INDUCTION COIL

(See figs. 79 and 80.) This also is in both receiver and transmitter circuits. Its function is to change the low-voltage battery current in the transmitter circuit to a high-voltage current which goes out on the line. This change is necessary because the voltage (or pressure) furnished by the three dry batteries in the transmitter circuit is too low to overcome the resistance. It is very seldom that an induction coil gets out of order—only when a wire is burned out by lightning. In this event it should be replaced with a new coil.

### CONDENSER

The condenser is made of strips of tin foil separated by thin sheets of paraffined paper. It has a high resistance to the ringing current, but practically none to the talking current. A telephone will work just as well without a condenser as with it. However, in this event when the receiver of the telephone is taken off the hook a circuit is connected to the line by means of the hook switch, which would include only the receiver and the secondary winding of the induction coil. (See fig. 75.) As their combined resistance is only about 150 ohms, it would result in a very bad ground on the line if the receiver should be left off the hook. This is shown graphically in Figure 88.

Condenser trouble seldom occurs. However, lightning may either burn it out (open) or "short-circuit" it. If burned out, one can neither talk nor receive over the telephone, but there will be no interference with the ringing. If a condenser is thought to be open, put a wire across the two condenser terminals. If this is the trouble, one will then be able to talk. If, on the other hand, a condenser is short-circuited, no difference will be noticed in the talking or receiving, but there will be a ground on the line, as previously stated. Also the generator crank will turn very hard if the receiver is left off the hook. In either event the defective condenser should be replaced with a new one.

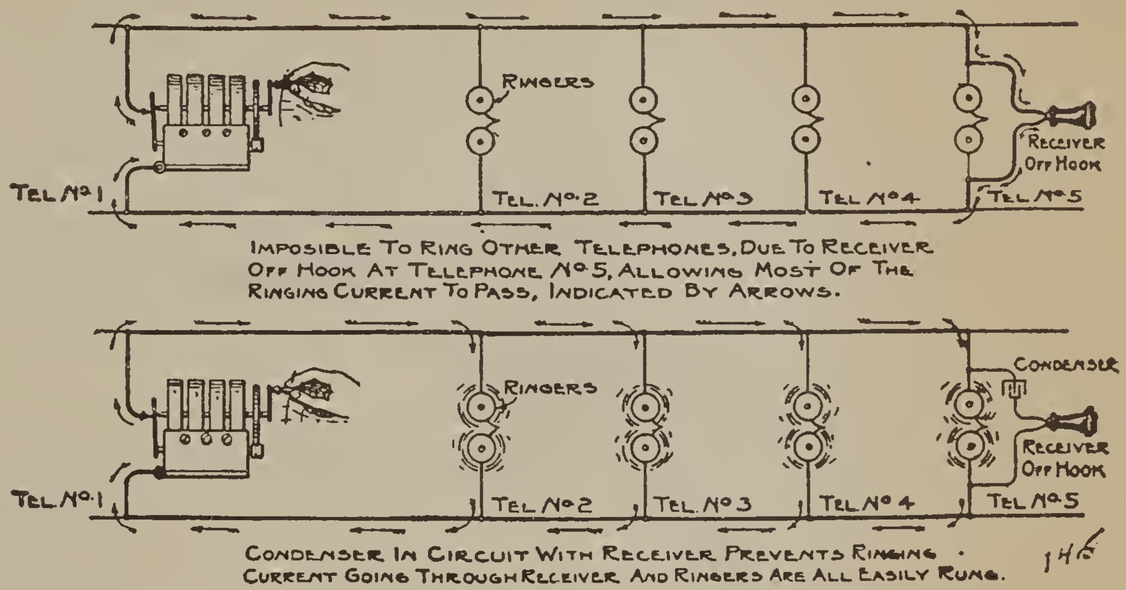



FIG. 88.—Illustrating function performed by a condenser in the receiver circuit

### ADJUSTMENT OF ADAMS'S PORTABLE TELEPHONE

The Adams portable telephone set occasionally gets out of adjustment as a result of rough usage, and it is sometimes necessary for field men to readjust it before successful signaling can be accomplished. This portable set signals to what is known as a howler at a distant point by means of a high-frequency current. In Figure 89 the details of the parts that occasionally need adjustment are shown. The vibrating-spring assembly operates the same as the clapper of an electric bell.

This vibrator assembly is attracted by the pole piece, which is energized magnetically by an electric current passing through the induction coil. In making the adjustment the best results are obtained by securing as high a frequency as possible. When this is obtained, a sharp buzzing noise should be heard from the vibrator spring. To adjust this spring properly, the lock-screw clamp should be first loosened. A screw driver should be used to turn the contact screw very slightly to the right or left while the signal button is being depressed. When the

proper tone is secured, the lock screw should be tightened to prevent the contact spring from being jarred loose. It should be noted, however, that the tightening of the lock screw will change the adjustment between the contact screw and the vibrator spring. In order to avoid this, the contact screw should be left just a little looser than desired before the lock screw is turned up. After this adjustment is attempted the amount of play to the left can readily be determined. Do not, however, attempt to turn the *contact screw without loosening the lock screw*, as the contact screw is likely to be damaged. In order to secure the best results with the Adams portable telephone, an adjustment should be maintained which will secure the highest frequency possible, as the higher the frequency the farther it will be possible to signal. Before any change is made in adjustment be sure to have a good battery. (Dry batteries should *always be removed* from all portable telephones at the end of the field season.)

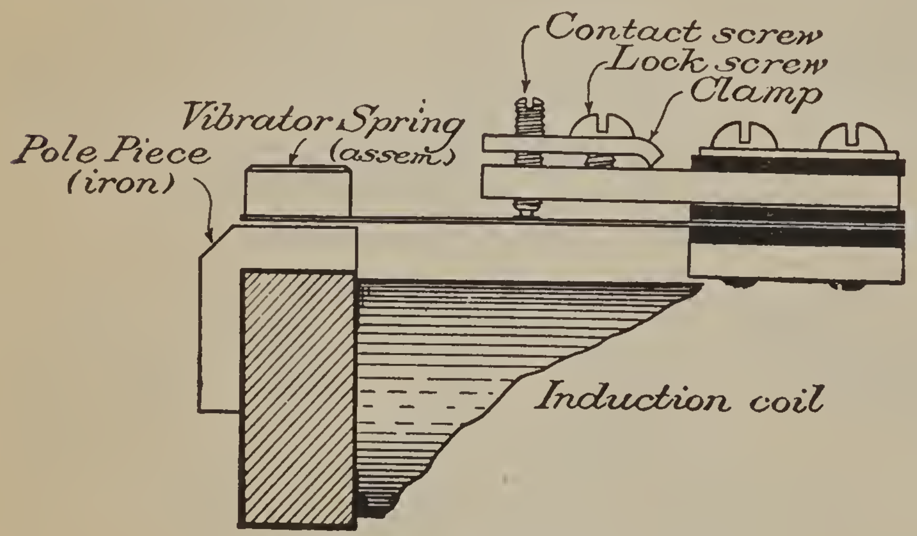



FIG. 89.—Adams's portable telephone

## TELEPHONE TROUBLES

The most common telephone "troubles" are caused by either grounds, broken wire, loose connections, or crosses (short circuits), and are most likely to be found outside on the line or in the ground connection. Poor instrument grounds are responsible for much of the ringing difficulty. Trouble may also occur in the telephone itself, from any one of the above causes, or as a result of weak batteries. The first step is to determine whether the trouble is on the line or at some telephone station.

1. A ground on any part of a line will interfere more or less with the proper operation of all telephones on that line. It will affect the ringing more than the talking, making it difficult or impossible to ring others.

2. An "open" (loose connection or broken wire) will make it impossible either to ring or to talk between telephones on opposite sides of the break; but will not interfere with the operation of the line between telephones on the same side of the break.

3. A cross or short circuit in a metallic line will have practically the same effect as a bad ground on the line. Following is a list of some of the most common telephone troubles, with brief instructions for making tests to determine their location. In a general way the entire telephone circuit is considered as being divided into sections, the tests definitely locating the trouble either in or out of a section. The telephone is usually tested first; then the protector, inside wiring, fuses, etc., and then the outside wiring, line wires, ground, etc.

While a Wheatstone bridge or a voltmeter test set will be of assistance in the hands of the experienced trouble man, the regular telephone magneto can be used to very good advantage in making some of these tests.

The function of the magneto is to generate electric current. It turns hard or easy in direct proportion to the amount of current (load) generated, and this in turn is inversely proportional to the resistance of the wires connected to the magneto.

A heavy ground on a line (or cross between line wires) is a low-resistance connection to the line wire, allowing much more than the normal current to flow through the line wire, which causes the generator to turn hard.

If the ground (or cross) is close to the telephone at which the tests are made, the bells at that telephone will not ring when the magneto is turned, as the low-resistance circuit made by the ground will take all of the current.

The same ground (or cross) on the line 10 miles farther away will not cause the magneto to turn so hard and the bell may ring a little, since the resistance in the line wire tends to retard the current. On the other hand, the magneto will turn easily if the line wire is broken close to the testing telephone, as there is then practically an open circuit; that is, no path for the current to pass, except through the ringer coils at that telephone, and very little current will be generated.

(1) Your magneto turns hard; it does not ring your own bell as it should and you can not ring others. This trouble may be caused by:

(*a*) Line wire (if it is a grounded-circuit line) touching trees, or brush, or on the ground; or if it is a metallic-circuit line, a cross between the wires, or both wires touching brush or on the ground.

(*b*) A grounded lightning protector (open space or 60–B type) at any station on the line.

(*c*) Ground or short circuit between spring contacts in magneto contact assembly (see "Magneto") due to insulation being burned out or injured by oil.

(*d*) Telephone left off hook at a telephone having no condenser in the receiver circuit. (See fig. 89.)

(*e*) Too many telephones connected to a line.

(*f*) A telephone with a low-resistance ringer coil connected to the line. (See fig. 45.) Make test as follows: Leave the receiver on the hook and disconnect the line wire (or wires) from the telephone.

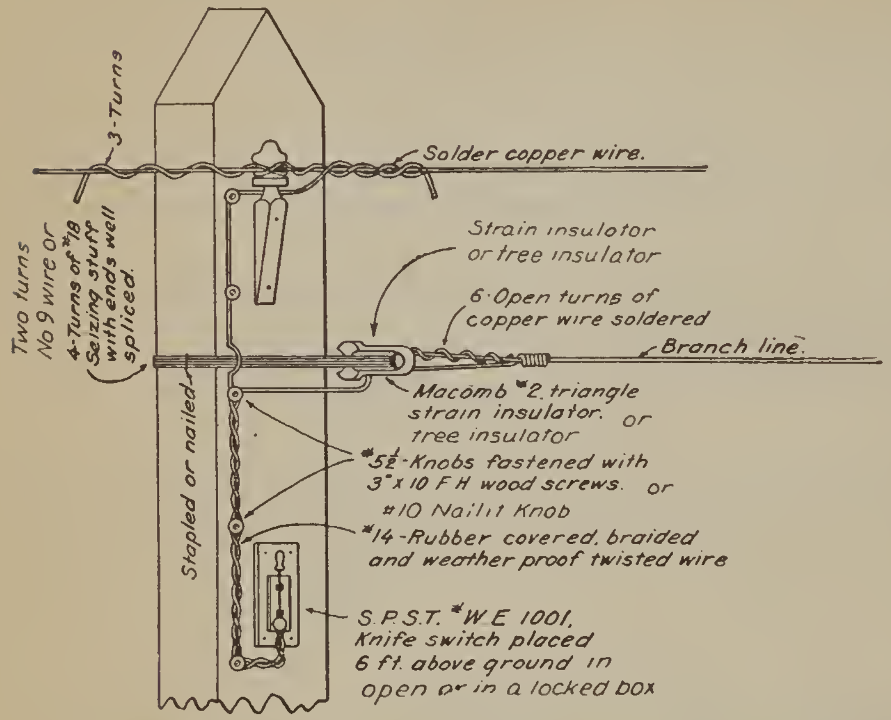



FIG. 90.—Out-of-door method of attaching branch lines

If the trouble is in the telephone, the generator will still turn hard; if the trouble is not in the telephone, it will turn easy. In the latter case it indicates that the trouble is ahead. Then the wires should be reconnected and another test made by disconnecting the insulated wires from the line wires outside of the building and turning the generator again. If the generator now turns hard, it indicates that the trouble is between the telephone, where the first test was made, and the connections between the insulated wire and the line wire, where the last test was made. If this is the case, the lightning protector (if it is of the open-space type) should be inspected and the inside wiring gone over carefully, looking for crossed wires.

If the generator turns easy, when making the last test, it indicates that the trouble is ahead, probably caused by a cross or line wire down on the ground. In this event it will be necessary to go over the line. If the trouble is not located readily, as, for instance, it may be at another station on the line, the line wire should be tested section by section, using the same method as above described to facilitate line testing; it is good practice to arrange for convenient switching off of branch line. (Fig. 90.)

(2) You can not call anyone, nor can anyone call you. Your generator turns easily and rings your own bell. You can hear no one on the line. This indicates an open line.

This trouble is usually caused by a broken wire, a burned-out fuse, or a loose connection. Test as follows:

Leave the receiver on the hook, and with a short piece of wire ("jumper") make a connection (short circuit) between the binding screws ($L_1$ and $L_2$) inside the telephone. Then turn the generator. If the trouble is in the telephone, the generator will still turn easy. In this case it will probably be found that the binding screws ($L_1$ or $L_2$) have worked loose or the insulated line wires have broken at these screws. If the generator turns hard, the trouble is ahead. In this event put on a "jumper" between the line and ground wires (or between the two line wires, if the line is metallic) just outside of the building and test with the generator as before. If it turns easy, it indicates that the trouble is between the telephone and the point outside where the last "jumper" was put on. In this event look for a burned-out line fuse or a broken or loose connection in the inside wiring or switches. In case the generator turns hard it indicates that the trouble is still ahead. In this event it will probably be caused by a broken ground or line wire.

(3) Your bell rings and when you place the receiver to your ear you can hear others, but they can not hear you at all, or perhaps only faintly. This can only be trouble in the transmitter circuit. (See figs. 75 and 79.)

(*a*) Weak batteries (one bad one may cause the trouble).
(*b*) Batteries improperly connected.
(*c*) Transmitter "set" or "packed."
(*d*) A broken wire in the telephone.
(*e*) Switch-hook contact springs dirty or not making contact.

The first step will probably be to "shake up" the transmitter. Then if the trouble is still on look at battery and battery connections. If batteries seem to be all right and properly connected, test the transmitter as indicated in Figure 81. The regular solid-back type of transmitter seldom gets out of order, and ordinarily should not be tampered with. If no sound can be heard when the transmitter is tapped, look for broken wire in the primary or battery circuit.

(4) Your telephone bell rings, but you can not hear anything when you place the receiver to your ear. This trouble will probably be in the receiver circuit in the telephone. (See figs. 79 and 80.) It may be caused by the following conditions:

(*a*) Dirt in the receiver.
(*b*) A dent in the receiver diaphragm.
(*c*) A broken wire in the receiver circuit.
(*d*) A loose connection.

(*e*) A burned-out condenser.
(*f*) Switch-hook spring contacts out of adjustment.
(*g*) Receiver cord loose in receiver.
(*h*) Fine wire in receiver coils burned out by lightning.

Methods of testing the receiver cord and the receiver are described under "Telephone testing." If it is found that there is a broken wire in the receiver cord, two short pieces of small, insulated wire may be used until a new receiver cord can be secured.

(5) You can not ring others well, nor can others ring you well. Your generator turns easily and rings your bell well. You may be able to talk and to hear others fairly well.

On grounded lines this trouble will ususally be caused by a poor ground connection. However, poor connections in the inside or outside wires of either a ground or metallic line will cause the same trouble. As it is difficult to test the ground connection, the most satisfactory way to locate this trouble is to test for a poor connection first. Do this in practically the same manner as described in trouble No. (2). If these tests indicate that the inside wires and line connections are all right, the surest way is to make a new ground connection.

(6) No one can ring you, but you can ring others. Your generator turns easy, but does not ring your own bell. You can talk and hear others.

This trouble may be caused by lightning burning out the wire in the ringer coils, by a faulty bell adjustment (as described under "Telephone testing"), or by a loose connection or broken wire in the ringer circuit in the telephone. (See fig. 79.)

In order to test the ringer coils, disconnect the instrument wires from both the ringer and the generator. Take two short pieces of wire and connect the generator directly to the ringer; then turn the generator. If the bell does not ring, it indicates that the fine wire in one or both of the ringer coils has been burned out. In this event take them out of frame and substitute good coils. This, however, should not be attempted unless soldering outfit is at hand. Better to have a few extra complete sets, including ringer frame and coils available, except gongs and nuts. The new set can be easily substituted, and later a good coil put in the old frame when convenient. It may be possible to make temporary repairs by removing the paper cover from the coils and connecting the burned ends of the fine wire.

(7) You can not ring others, but others can ring you. Your generator turns easily, but your own bell does not ring. You can talk and hear others.

This trouble is probably caused by broken wire at the binding screws of the generator. To make sure that the generator is working properly, test it as described under "Telephone testing." If the generator is working properly, the electric current it generates when the handle is turned will produce a decided prickly sensation in the ends of the fingers. If this is felt at the generator terminals, but not at the line binding screws, it indicates that there is a broken wire or loose connection between these two points.

If no current can be detected at the generator terminals when the handle is turned, examine the spring contacts to see that oil or dust has not collected on them. If they are all right, the generator should be gone over carefully by an experienced telephone man.

(8) You ring on one line at a switching station and the extention bell on another line rings, although you have not connected these two lines together. This trouble is caused either by a poor ground wire or poor ground connection. If the ground wire and connection are all right, make a new ground for one of the lines.

(9) You are carrying on a conversation with some one at another telephone, and the voice is chopped off—broken. If you hear the other person all right but your voice is broken, look for a loose connection in the transmitter circuit of your telephone. If your voice is not broken but the other person's voice is broken, the trouble is in the other transmitter circuit. If both voices are broken the trouble may be caused by:

(*a*) A loose connection in the receiving circuit of either telephone.

(*b*) A loose connection in the inside wiring, lightning protector, fuses, or ground connection at either telephone station.

(*c*) A line wire loose from tie and swinging against a ground wire or another line wire.

(*d*) A broken or partially shorted receiver cord at either telephone.

(*e*) A switch hook at either telephone with spring contacts not functioning properly.

(*f*) A loose connection in the drop wire at either station or in the line wire between these stations

(*g*) A bad connection in the line wire.

## MAINTENANCE

In order to secure good telephone service, the lines must not only be constructed according to the standards laid down in this handbook, but they must be kept in as good condition as when first built.

Do systematic maintenance. Go over all lines, inside wires, switches, telephones, etc., each spring. Read carefully the following general instructions before starting work.

## MAINTENANCE, TREE LINES

Study instructions for tree-line construction. It is important that district rangers take an active part in the maintenance of the telephone system of a forest. Keep lines currently maintained.

### DOWN TIMBER

Remove all limbs or trees that may be down over the line, or that are likely to fall on the wire during the field season. Brush must be disposed of so as not to form a fire menace. See that line wire has not been injured and that when cleared it swings back in place.

### BRUSHING OUT

Trim all brush, limbs, etc., so that they can not come to within 3 or 4 feet of line wire, making due allowance for wind, rain, and snow. Young cottonwoods, alders, etc., that will eventually grow into the line wire should be removed.

### TIE WIRES AND INSULATORS

Inspect all insulators and ties. Replace broken insulators; see that tie wires are twisted tight around insulators. Also see that ties are hooked into staples so that they will pull loose readily without breaking line wire. If an insulator is on the wrong side of a tree (that is, if line wire pulls against instead of away from it), either put in a tree pin, swing another insulator from a near-by tree and pull line wire clear, or change insulator and wire to the other side of tree.

### CONNECTIONS

Examine line wire closely for loose or rusty splices. If found, they should be cut out and good connections made.

### BREAKS

Try to find out what caused the break, and if possible make changes to avoid a repetition of the trouble.

### SLACK

There should be enough slack in line wire to permit its being pulled to the ground readily in any span. If wire is too tight, put in more slack.

## TIES PULLED OUT OF STAPLE

Examine tie wire. If damaged, put on new tie wire and hang properly. If trouble is due to strain caused by sharp bend in line wire, put on two insulators or change tie wire to another tree.

## DROP WIRE

(Wire extending from house to line wire, fig. 46.) See that there is enough slack to allow for tree or pole sway and that the wires (if more than one) are far enough apart to prevent crossing. If service wire is copper, connection to line wire must either be soldered or made with a Fahnestock connector, as shown on page 57. If service wire is iron, connection need not be soldered, but should be made with 8 or 10 close wraps around the line wire.

## LINE FUSES

See that line fuse is properly located. (See fig. 46.) Tighten up connecting nuts on each end of fuse and see that connection with line wire is properly made.

## TOOLS AND MATERIALS

Following is a list of tools and material suggested as necessary for tree-line maintenance:

*Two-man crew*

### TOOLS

1 light 12-foot ladder or 1 pair climbers.
1 pair 8-inch pliers.
1 pair connectors.
1 double-blade ax.
1 2½-pound single-blade ax, short handle.
2 small 2-sheave pulley blocks.
2 Klein's or Buffalo grips.
40 or 50 feet ⅜-inch rope.
1 lineman's belt.
1 lineman's safety strap.

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### MATERIAL

Supply of No. 9 iron telephone wire, seizing strand (or No. 12 if line is No. 12 or if tie wires are No. 12).
Supply of 3-inch staples, tree hook, etc.
Supply of split insulators.
Supply of 47–A line fuses.
A few tree hooks.

## MAINTENANCE, POLE LINES

Study instructions for "Pole line construction."

### POLES

Inspect each pole for rot at ground line. Test by pushing against side of pole with shovel; if it is not safe, stub or set new pole. Straighten up leaning poles unless raked intentionally. Put on extra guys if needed.

### GUYS

See that all guys are pulled up tight and that wire is in good condition, not rusted where it goes into the ground, etc. If guy is in road or other exposed place, guard stick should be wired to it just above the ground.

### LINE WIRES

Cut out bad splices and pull up slack so that all wires have same tension. See that there is sufficient clearance above the ground at road crossings. Put on new ties where needed and see that crossings with railroad tracks or electric-power wires are in good shape.

### LIGHTNING CONDUCTORS

See that wire is securely stapled to pole in proper position and is not rusted off where it enters the ground.

### BRACKETS AND INSULATORS

Replace broken insulators. If brackets are pulled off or loose, nail back in proper place. If brackets are split, put on new ones or use bracket clip. (Fig. 28.)

## TOOLS AND MATERIAL

Following is a list of tools and material suggested for pole-line maintenance:

### TOOLS

1 5-foot round-pointed shovel.
1 hand ax.
1 pair climbers.
1 pair pliers, 8-inch.
1 pair connectors.
1 lineman's belt.
1 safety strap.
2 small 2-sheave pulley blocks.
2 Klein's or Buffalo grips.
50 feet ⅜-inch rope.
1 tamping bar.

### MATERIAL

Supply of wire (same size as line wire), glass insulators, brackets (or cross-arm pins), and spikes.

# MAINTENANCE, INSIDE WIRING AND INSTRUMENTS

Study instructions for installing telephones and making a ground.

## INSULATED WIRE

All insulated wire from line fuse to the telephone should be rubber-covered, single-braided, copper wire. If wire of inferior quality is used, it should be replaced. If the wire hangs loose and is run in a careless manner, fasten neatly and securely in place with insulated tacks.

## CONNECTIONS

Examine old connections carefully; if not properly made and either soldered and taped, cut it out and make a new connection. Tape all bare places.

## LIGHTNING PROTECTORS

Lightning protectors should be on the inside of the house close to where the wire comes through the wall. If they are of the open-space type (60–E or 60–B), inspect them carefully. Unscrew the brass cap and take out the block. (If of carbon, replace them as soon as possible with one of copper alloy.) See that they are cleaned and that the mica strip is between them when they are put back in place. Tighten up binding screws that hold the wire. If vacuum type of arrester is used, see that all connecting nuts are tight.

## SWITCHES

Go over all screw contacts and see that the knife blades work freely and fit tight in the spring clips. If necessary to make them fit tight, bend the spring clips together. Change switches if they are not in good shape.

## GROUND CONNECTIONS

Go over ground wire and connections carefully. See to it that the connections are all soldered. This is very important. See that the ground is moist and made according to instructions. Do not forget that soil that is moist in the spring may be dry and make a very poor ground in the summer.

## EXTENSION BELL

See that binding screws are tight. Test bells and make adjustments if necessary when telephone is tested.

## BATTERIES

New batteries should be put in each spring and dated.

## TESTING TELEPHONE

Study section on "Telephone testing." See that all screw contacts with the telephone are tight. When the work is completed, make final tests as follows: Disconnect line wires from the line binding screws $L_1$ and $L_2$, and test magneto and bell by turning generator crank. If bell does not ring properly, look for trouble. (See "Telephone trouble.") Put a drop or two of oil at each end of the bearings (see fig. 84), and see that the spring contacts at the end of the generator work properly, as described under "Magneto adjustments."

Remove the receiver from the hook and work the switch hook up and down, leaving the door of the telephone open to see if the three spring contacts function properly, as described under "Switch hook." Make final test by calling up some other station on the line and see if you can talk with it satisfactorily, having it ring your bell. If signals do not come in clearly, make adjustments in telephone bell (extension bell also if there is an extension bell). Inspect receiver and see that it is in good condition; unscrew cap, and clean out dust under diaphragm.

## TOOLS AND MATERIALS

Following is a list of tools and material suggested for inside wiring and instrument maintenance:

### *One-man crew*

#### TOOLS

1 medium-sized screw driver.
1 pair of 8-inch pliers.
1 pair long-nose pliers, 5″.
1 pair side-cutting pliers, 6″.
1 blowtorch.
1 soldering iron.
1 small hammer.

#### MATERIAL

A supply of No. 14 rubber-covered copper wire.
A roll of tape.
1 box Blake insulated staples.
3 or 4 feet or 7/32-inch circular loom.
Wire solder.
Solder paste.
Small supply of tin foil.
1 or 2 receiver cords.
Extra blocks and mica strips for 60–E protectors.
Extra Fahnestock connectors (No. 9 copper, No. 9 iron).
Extra 47–A line fuses.
Extra knife switches of the type used.
A supply of 1-inch No. 8 roundheaded screws.
3 dry batteries for each telephone.

## TREATMENT OF EMERGENCY WIRE

Emergency wire or Army outpost wire which has been used during a field season should be worked over before the next field season and put in shape for use. Rewind each spool, cut out all bad joints, and make good

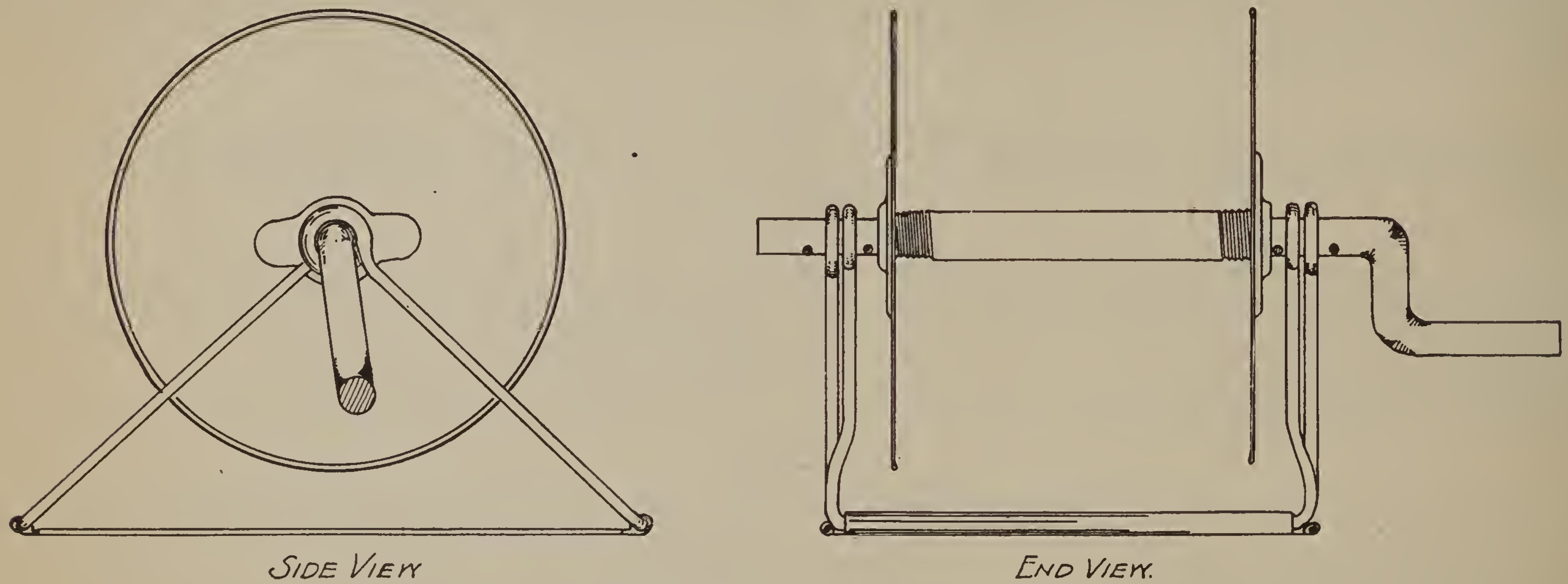


FIG. 91.—Emergency-wire take-up reel and metal spool

soldered splices instead. Tape all bare places. Do not use spools in bad condition. New spools for the emergency wire can be made at a cost of from 75 cents to $1 each. (See figs. 91, 92, and 93.)

After the wire is rewound dip the full spool into a hot mixture composed of beeswax with a small per cent of paraffin. Heat the mixture to about the boiling point (180° to 200°) and have the spool of wire completely

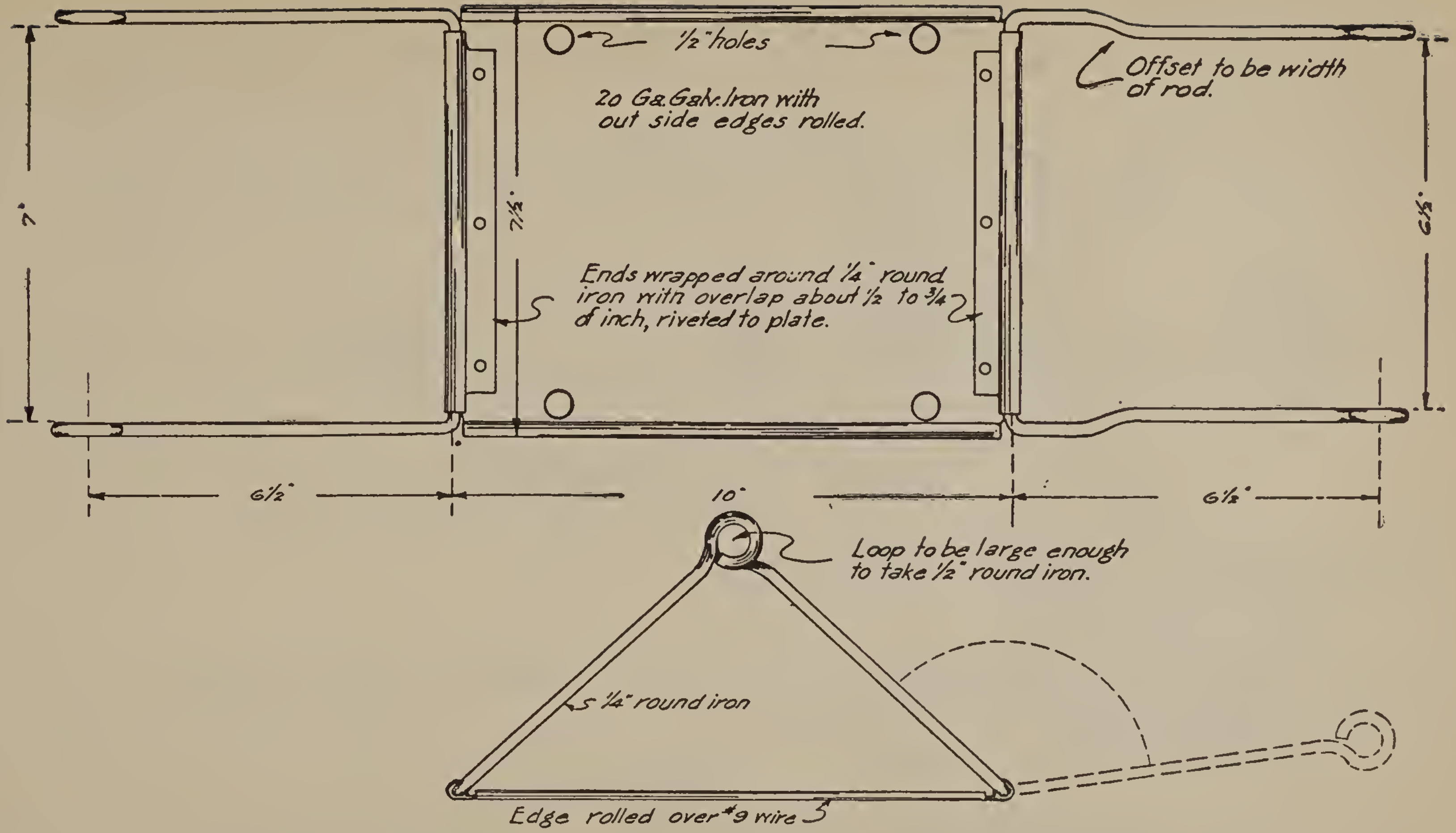


FIG. 92.—Take-up reel for small emergency wire. For take-up reel to hold spools of outpost wire, dimensions should be about doubled. Use ⅜-inch round iron and 18-gauge galvanized iron

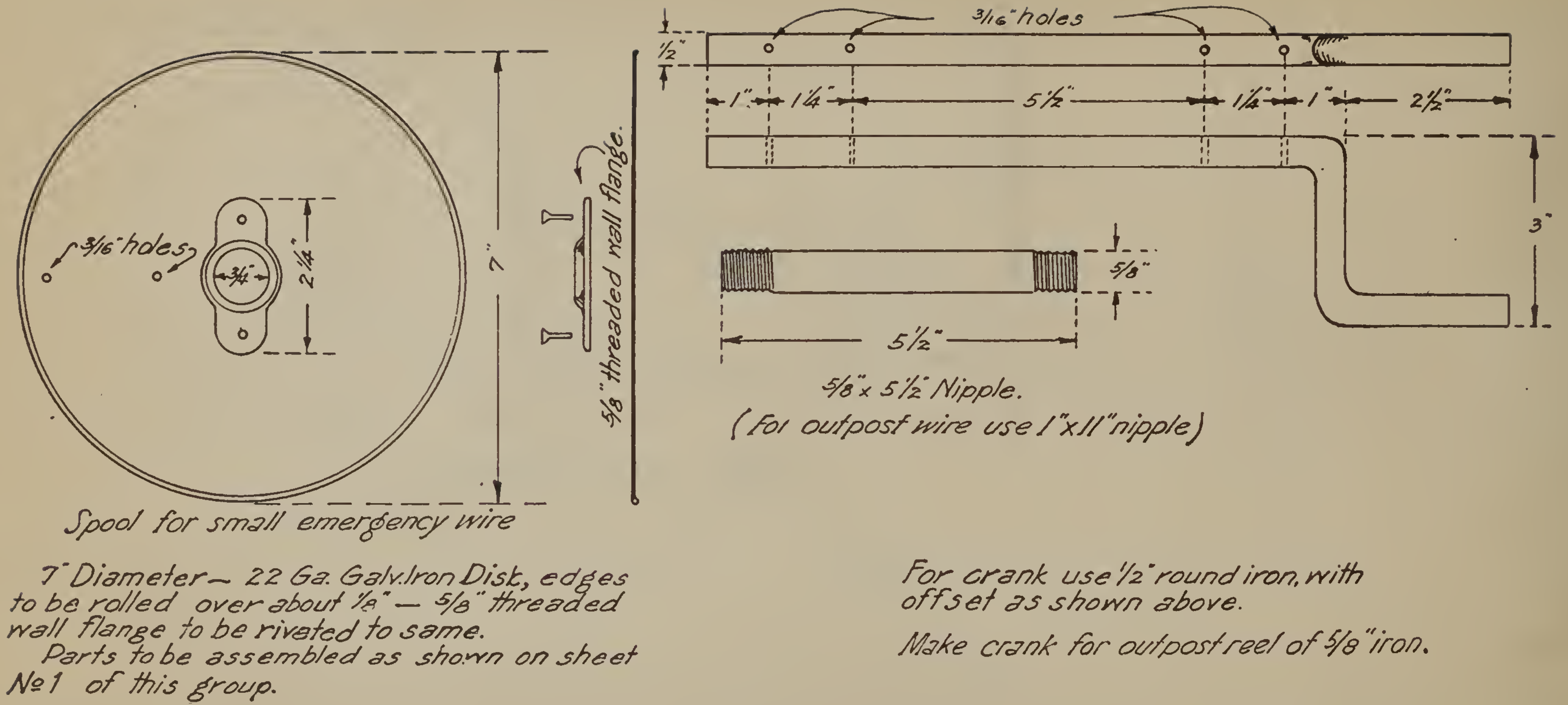


FIG. 93.—Emergency-wire spool. For spool for outpost wire, double above dimensions. Use No. 20 galvanized iron with rolled or hammered edge. Use a 1-inch nipple and a floor flange instead of a waste nut at center

immersed long enough for the mixture to penetrate to the inside layers of wire, probably about five minutes. (Pouring the hot mixture over the spool of wire instead of immersing it in the mixture will also secure good results.) There is one-half mile of emergency wire on each spool and the insulation on it will absorb from one-fourth to one-half pound of the mixture.

The spools of "outpost" wire hold about one-third mile each and will probably soak up a pound of the mixture.

The trade name for this mixture is beeswax or "yellow wax" and may be purchased from either the Western Electric Co. or the Kellogg Switchboard & Supply Co., furnished in 1-pound cakes, size about 4 by 8 by 1¼ inches; cost, 45 cents per pound.

### *Telephone material and equipment list*

#### INSTALLATION MATERIAL AND EQUIPMENT

NOTE.—In order to save space, the following legend was prepared, showing from whom telephone material may be obtained. Attention is especially called to the fact that this legend applies to each page of the "Telephone material and equipment list."

○=District Forester.
□=Kellogg Switchboard & Supply Co.
△=Western Electric Co.
★=The Universal High Power Telephone Co., Carlton and Eddy Streets, Seattle, Wash.
◇=General Electric Co.

| | From— | Description, dimensions, etc. | Approximate weight | Approximate cost |
|---|---|---|---|---|
| Wall telephone<br>Order as follows: No. 2884 telephone, F. S. type. | □ | Has 6-bar magneto, 2,500-ohm ringer, condenser in receiver circuit without lightning arrester; requires 3 regular dry batteries. | 40 pounds | $20.25 |
| Portable desk telephone<br>Order as follows: No. 90-A desk stand, including No. 41 receiver and No. 2415 desk-set box. | □ | Has standard transmitter and receiver and 6-bar magneto. | 30 pounds | 21.60 |
| Grab-a-phone<br>Order as follows: Grab-a-phone set, including 12-L type transmitter, No. 2415 desk-set box with 6-bar magneto, 2,500-ohm ringer, and No. 28 condenser in receiver circuit. | □ | Includes magneto box and combined hand set with 10-foot cord; standard telephone for lookout house, may be used for office; requires 3 regular dry batteries. | 32 pounds | 21.70 |

INSTALLATION MATERIAL AND EQUIPMENT—Continued

| | From— | Description, dimensions, etc. | Approximate weight | Approximate cost |
|---|---|---|---|---|
| Portable field telephone. Order as follows: No. 1016 test set, F. S. special magneto set. | □ | 53 (5-bar) magneto, No. 78-G, 2,500-ohm ringer, push button in transmitter circuit, wood block guards for binding posts and receiver; Columbia No. 4 oval dry battery, 2 required. | 22 pounds | $21.45 |
| Wall telephone. Order as follows: No. 1317-S telephone. | △ | Has 5-bar magneto, 2,500-ohm ringer, condenser in receiver circuit without lightning arrester. | 35 pounds | 23.05 |
| Small wall telephone. Order as follows: No. 1305-M telephone. | △ | Has standard transmitter and receiver transmitter mounted on front of magneto box; has 5-bar magneto and 2,500-ohm ringer; requires 3 dry batteries; has no battery box. | 25 pounds | |
| Portable desk telephone set. Order as follows: No. 6004-B desk set, including No. 1020-AL desk-set box, No. 143-AW receiver, No. 323 transmitter. | △ | Includes 5-bar magneto, 2,500-ohm ringer | do | 24.10 |
| Extension desk bracket for portable desk telephone. Order as follows: No. S14 bracket with either No. 5 mounting for top of desk or No. 4 mounting for wall. | △ | Collapsible, opens to 36 inches; support attached by screws to side of desk. | 7 pounds | 3.85 |
| Portable field telephone (Adams), aluminum telephone. Purchase through D. F. Order as follows: No. 1004-A hand set. | △ | For talking and receiving and sending howler signals | 3 pounds | 48.00 |
| Dispatchers' desk telephone set, F. S. type. See Telephone Specification No. 10. Does not include magneto or bell.[1] | ★ | For dispatcher's or important ranger's stations where long-distance telephone is required.[1] | 10 pounds | 40.00 |
| Magneto and bell for dispatcher's set | □ | Is a 6-bar magneto with 2,500-ohm bell | | |

[1] See Figures 73 and 74.

INSTALLATION MATERIAL AND EQUIPMENT—Continued

| | From— | Description, dimensions, etc. | Approximate weight | Approximate cost |
|---|---|---|---|---|
| Single extra head receiver for dispatcher's set [2] | □ | 1 No. 4-C receiver, including No. 2 head band<br>1 No. 25 jack (mounted if not located on switchboard)<br>1 No. 107 operator's plug<br>1 No. 100-D cord [2] | 5 pounds | $8.00 |
| Double extra head receiver for dispatcher's set [2] | □ | 2 No. 46 receivers, including No. 3 head band<br>1 No. 25 jack (mounted or unmounted)<br>1 No. 107 operator's plug<br>1 No. 100-D cord [2] | 6 pounds | 10.00 |
| Howler, No. 1-C | △ | Wood base, 5½ by 3; horn about 6 inches high | 2 pounds | 10.10 |
| Condenser, No. 21-W; use with above howler | △ | $4\frac{7}{16}$ by 1¾ by $1\frac{5}{16}$ inches | 6 ounces | 1.10 |
| Condenser strap for No. 21-W condenser | △ | | | .05 |
| Howler, No. 4, F. S. type | □ | Howler and condenser on base 4 by 6 inches | 2 pounds | 5.90 |
| Extension bell, No. 127-F, 2,500-ohm | △ | 4⅝ by 6½ by 4⅞ with 2½-inch gongs | 5 pounds | 5.70 |
| Loud-ringing extension bell, No. 3923, 2,500-ohm | △ | 12 by 14 by 3 with 6-inch gongs | 15 pounds | 9.80 |
| Extension bell, No. 37-SG, 2,500-ohm | □ | 4¾ by 5½ by 4¾ with 2½-inch gongs | | |
| Loud-ringing extension bell, 2,500-ohm | □ | 2 6-inch gongs | 14 pounds | 8.00 |

[2] See Figure 74.

TELEPHONE REPAIR PARTS

| | From— | Approximate weight | Approximate cost |
|---|---|---|---|
| No. 1317-S telephone: | | | |
| No. 143-AW receiver | △ | | $2.10 |
| No. 92 receiver cord | △ | | .48 |
| Shell for No. 92 receiver | △ | | .48 |
| Cap, No. P93519, for No. 143-AW receiver | △ | | .32 |
| Diaphragm, No. P95114, for No. 143-AW receiver | △ | | .11 |
| Switch hook, complete, for No. 1317-S telephone | △ | | 1.30 |
| No. 38-B bell or ringer coils for either No. 1317-S telephone or 127-F extension bell | △ | | 2.85 |
| No. 48-A magneto | △ | | 9.45 |
| Spring contact for 48-A magneto | △ | | .75 |
| Crank for 48-A magneto | △ | | .50 |
| No. 323-W transmitter | △ | | 2.45 |
| No. 13 induction coil | △ | | 1.10 |
| Transmitter mouthpiece, No. P94590 | △ | | .11 |
| Extra screws for 1004-A (aluminum) head set, 3 by ⅜ inches, with 36 threads | △ | | |
| Repairs for No. 1336-E iron mine set: | | | |
| No. 144-AW receiver | △ | | 2.45 |
| No. 364 receiver cord | △ | | .35 |
| Cap for No. 144-AW receiver | △ | | .42 |
| Diaphragm for No. 144-AW receiver | △ | | .11 |
| No. 143-J switch hook for No. 1336-E iron mine set | △ | | 1.80 |
| No. 46-B ringer, less gongs and nuts | △ | | |
| Spring-contact assembly for No. 48-C magneto | △ | | .75 |
| No. 1312 transmitter | △ | | 5.60 |
| Mouthpiece for No. 1312 transmitter | △ | | .18 |
| Repairs for No. 1375 leather set: | | | |
| No. 366 hand-set cord, 3-conductor | △ | | |
| Magneto crank | △ | | |
| Magneto crank for No. 1375 field set | △ | | |
| Repairs for No. 1-C (Western Electric) howler: | | | |
| Extra coils for No. 1-C howler | △ | | .65 |
| Extra diaphragm for No. 1-C howler | △ | | .04 |

TELEPHONE REPAIR PARTS—Continued

| | From— | Approximate weight | Approximate cost |
|---|---|---|---|
| Parts for No. 2884 wall telephone: | | | |
| No. 64–L transmitter | ☐ | 1 pound | $1.85 |
| No. 41–A receiver with No. 242 cord, receiver switch-hook assembly | ☐ | 2 pounds | 2.00 |
| Bakelite mouthpiece | ☐ | | .20 |
| Bakelite receiver shells | ☐ | | .50 |
| Bakelite receiver caps | ☐ | | .25 |
| Generator, No. 75, 6-bar spring-contact assembly, for No. 75 magneto | ☐ | 15 pounds | 7.10 |
| Induction coils, No. 28–C | ☐ | | .60 |
| Ringers, complete, No. 78–G | ☐ | 2 pounds | 2.15 |
| Receiver cord, No. 242 ... per 100 | ☐ | | 28.75 |
| Parts for No. 1016 portable field set: | | | |
| Receiver cap for No. 1016 field set | ☐ | | .25 |
| Receiver shell for No. 1016 field set | ☐ | | .50 |
| Generator, No. 53, 5-bar | ☐ | 14 pounds | 5.00 |
| Ringer coils for extension bell or wall telephone | ☐ | | 2.05 |
| Order as follows: No. 78–G ringerless gongs. | | | |
| Oval batteries, No. 4, for 1016 bell or field set ... each | ☐ | | .38 |
| Generator cranks ... each | ☐ | | .20 |
| Parts for No. 90–A portable desk set: | | | |
| Receiver with brown cord, No. 41–A | ☐ | | 2.00 |
| Brown receiver cord, No. 98–TR ... each | ☐ | | .25 |
| No. 102–D brown desk-stand cord ... each | ☐ | | .72 |
| Bakelite mouthpiece ... each | ☐ | | .20 |
| Bakelite receiver shell ... each | ☐ | | .50 |
| Bakelite receiver cap ... each | ☐ | | .25 |
| Generator, No. 75, 6-bar, spring-contact assembly for No. 75 magneto | ☐ | 15 pounds | 7.10 |
| Ringer, complete, No. 78–G | ☐ | | 2.15 |
| Transmitter, No. 64–L | ☐ | | 1.85 |
| Generator cranks | ☐ | | .20 |

TELEPHONE REPAIR PARTS—Continued

| | From— | Approximate weight | Approximate cost |
|---|---|---|---|
| Parts for Grab-a-phone set: | | | |
| Grab-a-phone mouthpiece | □ | | $1.35 |
| Grab-a-phone cord, F454-G, 8 feet | □ | | 1.00 |
| Generator, No. 75, 6-bar | □ | 15 pounds | 7.10 |
| Ringer, complete, No. 78-G | □ | 2 pounds | 2.15 |
| Receiver cap, No. 30208 | □ | | .25 |
| Generator crank | □ | | .25 |

PRIMARY SWITCHBOARD MATERIAL

[See Telephone Specification No. 7]

| | | | |
|---|---|---|---|
| Plug, No. 44, single-conductor, for grounded circuit | □ | 2 ounces | $0.42 |
| Plug, No. 168, two-conductor, for metallic circuit | □ | do | .80 |
| Cord, No. 310 (36 inches), single-conductor, for grounded circuit | □ | do | .40 |
| Cord, No. 304 (36 or 48 inches), two-conductor, for metallic circuit | □ | do | .80 |
| Cord weight, No. 9, for either 310 or 304 cord | □ | do | .40 |
| Jack, No. 25, three-conductor, for either No. 44 or No. 168 plug; jack to be fitted with sleeves and washer for mounting on ⅛-inch jack-mounting strip. | □ | 3 ounces | .75 |
| Jack-mounting strip, bakelite, bored for No. 25 jacks; with screws for attaching strip to switchboard | □ | | [3] .35 |
| Terminal-strip binding posts [4] mounted 1 inch apart on hardwood strip; specify number of binding posts required. | □ | | [5] .05 |
| Wire (for wiring switchboard), No. 20 tinned telephone wire with double-wound paraffin cotton insulation | □ | 7 pounds per M feet. | [6] .90 |
| Line markers, approximately ¾ by 2 inches | □ | | .05 |
| Key, No. 1033, nonlocking, one-way double-pole | □ | | |
| Key, No. 1030, locking, two-way double-pole | □ | | |

[3] Cost per hole. [4] Binding posts No. 11 (□) and No. P36887 (△) not mounted on strip. [5] Cost per binding post. [6] Cost per pound.

PRIMARY SWITCHBOARD MATERIAL—Continued

| | From— | Description, dimensions, etc. | Approximate weight | Approximate cost |
|---|---|---|---|---|
| Telephone dry batteries | ○ | 2½ by 6 inches | 2¼ pounds | $0.35 |
| Columbia small oval dry battery for Kellogg portable field set, 2 required. | ○ | 4½ inches high, 2¼ inches wide, 1⅜ inches thick. | 2 pounds | .50 |
| No. 705 Ever-Ready battery, 3-cell | ○ | For 1004–A aluminum portable telephone. | | .30 |
| No. 790 Ever-Ready battery, 2-cell | ○ | For special Army field telephone, 2 required. | | .20 |
| No. 751 Ever-Ready battery, dry | ○ | For 1375–A leather portable telephone | ½ pound | .25 |
| Knife switches: | | | | |
| S. P. S. T. (single-pole, single-throw) | □△ | 3¾ by 1⅛ inches | 29 pounds per 100 | .25 |
| S. P. D. T. (single-pole, double-throw) | □△ | 4¼ by 1⅜ inches | 41 pounds per 100 | .38 |
| D. P. S. T. (double-pole, single-throw) | □△ | 3¾ by 2 inches | 43 pounds per 100 | .45 |
| D. P. D. T. (double-pole, double-throw) | □△ | 5 by 2⅝ inches | 80 pounds per 100 | .70 |
| Repeating coil | □△ | No. 17–F metal base with wood top, 3¾ by 3$\frac{1}{32}$ by 3¾ inches | 6 pounds | 7.25 |
| Do | △ | No. 77–A on wood base, 6 by 4½ by 3 inches. | 5 pounds | 6.05 |
| Howler set, F. S. type (special howler signal set), induction coil and interrupter with key or push button for operating; used to produce high-frequency electric-current impulses for operating howlers. | □ | (See fig. 70.) | 4 pounds | 4.75 |

INSTALLATION MATERIAL AND EQUIPMENT

| | From— | Description, dimensions, etc. | Approximate weight | Approximate cost |
|---|---|---|---|---|
| Line fuses | □△ | 47–A | 25 pounds per M | \$0.26 |
| Insulated wire for inside (or short spans outside) | □△ | 14–RCSB copper, rubber-covered, single-braid. | | [6] 8.00 |
| Twisted-pair drop wire for outside use | □△ | Is a rubber-covered wire, No. 16 guage | | [6] 15.00 |
| Loom; use instead of porcelain tubes | □△ | $\frac{7}{32}$-inch diameter | | [7] .07 |
| Lightning arrester, or protector vacuum | □△ | Brach | 4 ounces | 2.75 |
| Do | □ | No. 148057 | 6 ounces | 2.00 |
| Lightning protector parts for 60–E protector, No. 10 mica and Nos. 19 and 20 copper blocks. | | | ½ pound | .16 |
| Solder; rosin core, for switchboard work, acid for other work | □△ | Wire solder | | [8] .50 |
| Tape, friction | □△ | ½-pound rolls | | [8] .40 |
| Insulated staples, ¾-inch | □△ | ¾ for 14-RCSB copper wire | | [9] 2.50 |
| Screws for extension bells | □△ | 1½, No. 6 or 8 R. H. blued | | |
| Fahnestock connectors, No. 30 | □△ | | 3 ounces | .10 |
| Specify as desired: Iron to iron, iron to copper, copper to copper. | | | | |
| Ground cone, No. 4 | □ | 2 by 6 by 2 | 10 pounds | 4.20 |
| Ground clamp, Blackburn's adjustable ground clamp, No. A–1 | □△ | ⅜ to 1¼ pipe | 4 ounces | .15 |
| All-in-one ground clamp, type E | △ | ⅜ to 2 | do | .15 |
| Ground rod, copper-clad steel, with No. 10 copper connecting wire attached. | □△ | ½-inch diameter by 6 feet long | 360 pounds per 100 | [10] 1.20 |

[6] Cost per 1,000 feet. [7] Cost per foot. [8] Cost per pound. [9] Cost per 1,000. [10] Each.

TREE-LINE AND POLE-LINE MATERIAL

| | From— | Description, dimensions, etc. | Approximate weight | Approximate cost |
|---|---|---|---|---|
| No. 9 iron wire | ○ | ¼ or ½ mile coils | 305 pounds to mile | |
| No. 12 iron wire | ○ | ½-mile coils | 165 pounds to mile | |
| No. 8 special steel river-crossing wire | ○ | Specify length desired | | |
| Galvanized thimbles | ○ | $\frac{5}{16}$-inch score, closed end | 7 pounds per 100 | |
| Seizing stuff | ○ | No. 18 galvanized Swedish iron | 46 pounds per M feet. | |
| Tree insulator, split | ○ | 1½ by 2¼ by 3 inches | ½ pound., 750 to barrel. | |
| Tree insulator, solid | ○ | do | do | $0.08 |
| Tree pins and hooks | ○ | (See figs. 3 and 4) | | |
| Wood bracket | □△ | ½ by 2 by 12 inches | 10 ounces | .04 |
| Glass insulator | □△ | 4 by 2⅜ inches | 14 ounces | .10 |
| Strain insulator, No. 500, for No. 9 wire or small guy | □ | 2¼ by 1½ inch holes, $\frac{5}{16}$-inch diameter | 6 ounces | [10] 10.00 |
| Strain insulator, No. 502, for heavy guy cable | □ | 2½ by 3 inch holes ⅜-inch diameter | 12 ounces | .16 |
| Crossarms, 6 pins | □△ | 3¼ by 4¼ by 72 inches, bored for 1¼-inch pins. | 20 pounds | 1.25 |
| Crossarm pins | □△ | 1 by 9½ inch W. U. steel pin, locust top | ¾ pound each | .04 |
| Machine bolts (crossarm) | □△ | ⅝ by 12 inches | 110 pounds per 100 | [10] 10.00 |
| Square washers | □△ | 2 by 2 by ⅛ inch, hole $\frac{11}{16}$ inch | | .02 |
| Knobs, porcelain (solid) | □△ | 1⅞ by 1⅛ inches | 4 ounces | .04 |
| Knobs, porcelain, Nailit | □△ | | do | .025 |
| Screws for above | □△ | 3 by No. 16 F. H. | | .10 |
| Crossarm braces, galvanized | □△ | 1$\frac{7}{32}$ by $\frac{7}{32}$ by 24 inches | 142 pounds per 100 | 10.40 |
| Carriage bolts, galvanized | □△ | ⅜ by 4 inches | 17 pounds per 100 | 2.10 |
| Lag screws, galvanized | □△ | do | 12 pounds per 100 | 2.15 |
| Double crossarm bolt, galvanized | □△ | ⅝ by 14 inches, ordinary size | 129 pounds per 100 | 18.40 |
| Guy clamps, 2-bolt, galvanized | □△ | For ⅜-inch strand guy cable | 115 pounds per 100 | 20.00 |
| Guy strand cable, galvanized | □△ | ⅜-inch | 30 pounds per 100 | [11] 3.00 |
| Do | □△ | ¼-inch | 50 pounds per 100 | 2.00 |
| Thimbles, galvanized | □△ | For ⅜ or ¼ inch guy cable | | |
| Transportation bracket | □△ | For 3¼ by 4¼ inch crossarm | 1 pound | 1.20 |
| Bracket clip | □ | (See fig. 28) | | |

[10] Each. [11] Cost per 100.

TOOLS AND EMERGENCY WIRE

| | From— | Description, dimensions, etc. | Approximate weight | Approximate cost |
|---|---|---|---|---|
| Special tree climbers | ☐ | (See fig. 25.) | 3½ pounds | $4.10 |
| Regular Eastern climbers | ☐ | Klein's, No. 1901 | | |
| Straps for climbers | ☐ | No. 5301, on E-strap | 1¼ pounds | 3.25 |
| Belts (specify length) 38, 40, or 42 inches | ☐ | No. 204 tool belt, 2¼ inches | 2½ pounds | 5.50 |
| Safety strap, No. 5251 | ☐ | 1¾ inches by 6 feet | 2 pounds | 5.55 |
| Pliers, 8-inches, No. 201-8 | ☐ | Side cutting | 1 pound | 3.85 |
| Pliers, 9-inches, No. 901-9, with splicing attachment on end | ☐ | Side cutting, F. S | 1⅛ pounds | |
| Diagonal-cutting pliers | ☐ | Klein's, No. 202-6, oblique cutting | 4 ounzes | 2.40 |
| Do | ☐ | Swedish, No. 526-6, oblique cutting | do | 1.75 |
| Long-nose pliers | ☐ | Klein's, No. 501-6, without side cutter | do | 2.00 |
| Do | ☐ | Klein's, No. 203-6, with side cutter | 5 ounces | 2.40 |
| Connectors, medium, 10½ inches | ☐ | No. 102-3 wire-splicing clamp | 11 ounces | 3.25 |
| Connectors, heavy, 10¾ inches | ☐ | No. 132-3 comb wire and clamp | | |
| Emergency wire, small stranded copper emergency, 7-strand copper equal to about No. 20 gauge. | ○ | Insulation thin double-wound cotton saturated with beeswax mixture, ½-mile spool. | 22 pounds per mile | 25.00 |
| Army outpost wire, 7-strand steel and copper equal to about No. 22 gauge copper. | ○ | Rubber and braided cotton insulation | 42 pounds per mile | |
| Beeswax and paraffin mixture for recoating emergency or outpost wire. | ☐ △ | Purchased in pound cakes, 4 by 8 by 1¼. | 1 pound | .55 |
| Metal spools to hold small emergency wire | | Available only on special order | | |
| Take-up reel to wind up small emergency wire | ○ | (See figs. 91, 92, 93) | | |

# MATERIAL-LIST INDEX